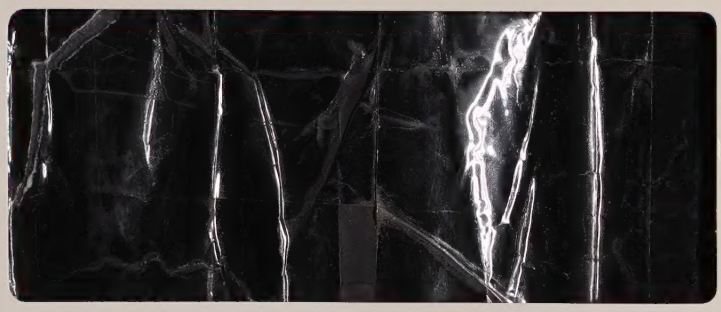
OPERATING AND SERVICE Manual



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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from date of delivery, or in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

MANUAL CHANGES

Model 6459A DC Power Supply
Manual HP Part No. 06459-90001

Make all corrections in the manual according to errata below, then check the following table for your power supply serial number and enter any listed change(s) in the manual.

SERIAL		MAKE CHANGES
Prefix	Number	
All	--	Errata
5C	1073-1099	1
5C	1100-1137	1, 2
5C	1138-1165	1, 2, 3
5C	1166-1181	1, 2, 3, 4
5C	1182-1255	1, 2, 3, 4, 5
1136A	1256-1263	1 thru 6
1149A	1264-1323	1 thru 7
1149A	1324-1433	1 thru 8
1149A	1434-up	1 thru 9

ERRATA:

Observe the following precaution when repairing the unit.

——— CAUTION ———

When replacing the SCR's, use a torque wrench with a 0-50 inch pound capability. All SCR's must be installed with a torque of between 20 and 30 inch pounds. A torque below 20 inch pounds may result in a poor connection between the SCR and heat sink and the SCR will run too hot. If more than 30 inch pounds is used, the SCR could be broken.

On page 3-2, in step (c) of paragraph 3-14, change the first sentence to read:

The output voltage will vary at a rate determined by the programming coefficient - 300 ohms per volt (i. e., the output voltage will vary 1 volt for each 300 ohms connected across the programming terminals.)

On page 3-2, in step (c) of paragraph 3-18, change the first sentence to read:

The output current will vary at a rate determined by the programming coefficient - approximately four ohms per ampere (i. e., the output current will vary one amp for each 4 ohms connected across the programming terminals.)

On page 3-3, in figure 3-6, remove the strap between terminals A9 and A10.

On page 5-6, in step (l) of paragraph 5-53, change the value of the programming resistance for the Model 6459A to 18KΩ.

On page 2-1 in paragraph 2-9, note that the minimum ac line protection capacity required for SCR firing current surges is 20 amperes for three phase 208/230Vac, and 10 amperes for three phase 460V ac operation.

CHANGE 1:

On page 1-2, after "Meters:", change current range from "0-50A" to "0-60A".

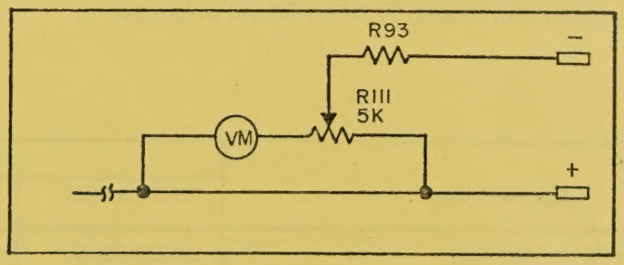
In the replaceable parts table at the rear of the manual, make the following changes:

R48: Change to 820Ω, ½W, AB.
R93: Change to 75KΩ, ½W, A B.
R111: Change to 10KΩ, Variable.
Meter, 0-80V: Change to HP Part No. 1120-1314.
Meter, 0-50A: Change to 0-60A, HP Part No. 1120-1317.

CHANGE 2:

In the replaceable parts table, change R93 to 56KΩ ±5%, ½W, HP Part No. 0686-5635.

On the schematic change voltmeter connections as shown in the sketch below.



CHANGE 3:

In the replaceable parts table, make the following changes for any Models with a 460Vac input (Option 03):

CB1 (460): Change to 10 amp, CD3-Z29-1, Heineman, HP Part No. 2110-0298.
R39: Change to 220KΩ, ±5%, 2W, HP Part No. 0698-3665.
Front Panel - 460Vac: Change to HP Part No. 06459-60003.
Add Cover, Ckt. Breaker: HP Part No. 5000-6227.
Add Base Plate, Ckt. Breaker: HP Part No. 5020-5742.

CHANGE 4:

In the replaceable parts table, change the HP Part No. of the fan motor (quantity 3) to 3140-0052.

CHANGE 5:

In the replaceable parts table, make the following changes for any models with 380Vac input (Option 31) or 400Vac input (Option 32):

CB1: Change to 10 amp 500V, quantity 1, CD3-Z29-1, 74193, HP Part No. 2110-0298.
R39: Change to fxd, met. film 220KΩ ±5%, 2W, quantity 1, Corning, Type C42S, HP Part No. 0698-3665.
Panel, Front: Change to HP Part No. 06459-60003.
Cover: Change to HP Part No. 5000-6227.
Base Plate: Change to HP Part No. 5020-5742.
Option 31 only:
Power Transformer T1: Change to HP Part No. 06459-80091.
Option 32 only:
Power Transformer T1: Change to HP Part No. 06459-80092.

ERRATA:

In the replaceable parts table, make the following changes:
CB1 (460Vac): Change HP Part No. to 2110-0298.
Add: CB1 (380V), 10A, HP Part No. 2110-0298.
CB1 (400V), 10A, HP Part No. 2110-0298.
(See HP Service Note P2110-0298 for instructions on how to install CB1 HP Part No. 2110-0298 in units that have been equipped with Options 03, 31, or 32 and which have obsolete circuit breakers.)
Barrier Strip: Change to HP Part No. 0360-1547.

CHANGE 6:

The serial prefix of this supply has been changed to 1136A. This is the only change.

CHANGE 7:

The serial prefix of this unit has been changed to 1149A. This is the only change.

CHANGE 8:

In the replaceable parts table, change the HP Part No. of CR12, CR13, and CR14 to 1884-0225. Also change R56, R64, and R72 to 10Ω, HP Part No. 0686-0335.

ERRATA:

The standard colors for this instrument are now mint gray (for front and rear panels) and olive gray (for all top, bottom, side, and other external surfaces.) Option X95 designates use of the former color scheme of light gray and blue gray. Option A85 designates use of a light gray front panel with olive gray used for all other external surfaces. New part numbers are shown below.

In the parts list for Option 06 (Crowbar Assembly), change the HP Part No. of CR3 to 1901-0317.

DESCRIPTION	HP PART NO.		
	STANDARD	OPTION A85	OPTION X95
Front Panel (208Vac)	06459-60004	06459-60001	
Front Panel (380Vac, 400Vac, 460Vac)	06459-60006	06459-60003	
Chassis Welding Assembly	5060-7969	←	
Chassis Output (208Vac)	5060-9603	←	Refer to
Chassis Output (230Vac)	5060-9604	←	manual
Chassis Output (460Vac)	5060-9605	←	parts list
Top Cover	5000-9488	←	
Capacitor Tray	5000-9487	←	
Circuit Breaker Cover (460Vac)	5000-9474	←	

ERRATA:

Add the following to the Table 1-1, Specifications:

Power Supply Output Restrictions as a Function of Loading: Under light loading conditions, the power supply may not meet all published specifications. The graph below defines the permissable operating regions for the CV and CC modes of operation. Note that for operation with a 50Hz input (Option 005), the output current is linearly derated from 100% at 40°C to 80% at 50°C.

In paragraphs 1-4 and 2-11, add the following ac input options:

Models 6453A, 6456B, 6459A: AC input may be delta or wye with isolated neutral. AC input connections are by means of Hubbell No. 7413G connector at rear of unit. A matching connector is furnished.

Option 001 – 208Vac ±10%, 3-phase, 15.5A per phase, 57-63Hz.

Option 002 – 230Vac ±10%, 3-phase, 14A per phase, 57-63Hz.

Option 031 – 380Vac ±10%, 3-phase, 8.5A per phase, 57-63Hz.

Option 032 – 400Vac ±10%, 3-phase, 8.0A per phase, 57-63Hz.

Option 003 – 460 Vac ±10%, 3-phase, 7A per phase, 57-63Hz.

Option 005 – Realignment for 50Hz operation at any of the above line voltages.

In replaceable parts table, change HP Part No. of pilot light DS1 to 1450-0566.

CHANGE 9:

In the replaceable parts table, make the following changes for models having 380Vac, 50Hz input (Options 031 and 005) or 400Vac, 50Hz input (Options 032 and 005).

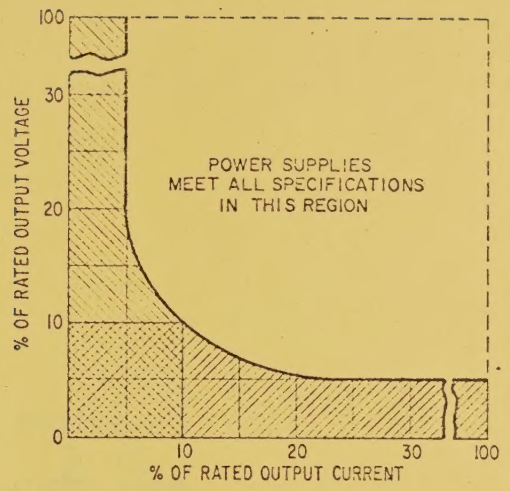
R60: Change to 11k, 5%, 1/2W, HP Part No. 0686-1135.

R68, R76: Change to 8.2k, 5%, 1/2W, HP Part No. 0686-8225 (qty. 2).

ERRATA:

Add the following notice to paragraph 1-13: "Effective December 1, 1975, extra manuals may be obtained by ordering Option 910 when ordering your instrument. The number of extra manuals depends on the number of Option 910s ordered."

▶ On the schematic, reverse the positions of resistors R95 and R112. R112 should be connected to current sensing resistor R96, and R95 should be connected to the ammeter.

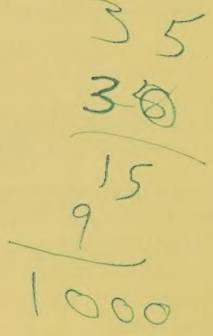


Power Supply Output Restrictions as a Function of Loading
(Refer to note § on specification pages)

Unspecified region for CC operation. Meets specifications in CV operation.

Unspecified region for CV operation. Meets specifications in CC operation.

Unspecified region for both CC and CV modes of operation.



DC POWER SUPPLY

SCR-3 SERIES, MODEL 6459A

SERIAL NUMBER PREFIX 5C

Stock Number: 06459-90001
Printed: May, 1967

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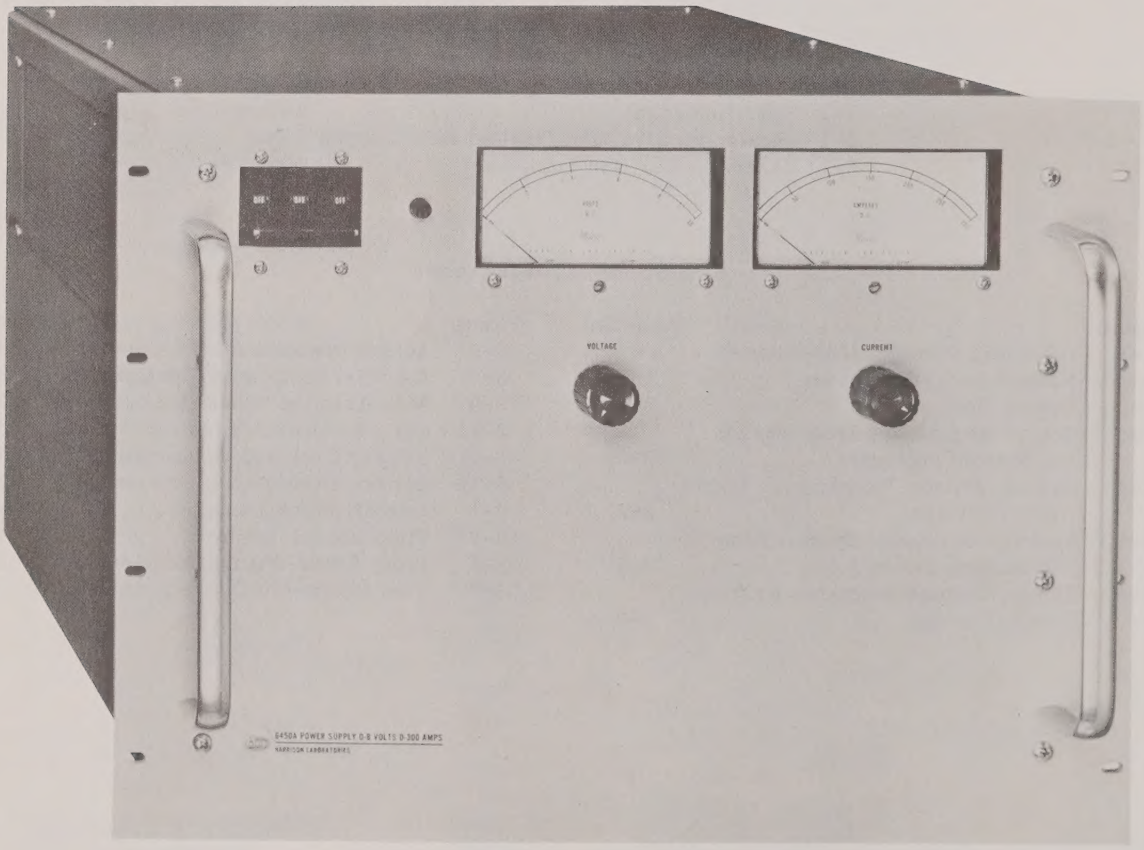


Figure 1-1. DC Power Supply, SCR-3 Series

SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 This power supply, Figure 1-1, is a completely transistorized, well-regulated, Constant Voltage/ Constant Current supply that will furnish full rated output voltage at the maximum rated output current or can be continuously adjusted throughout the output range. The front panel CURRENT controls can be used to establish the output current limit (overload or short circuit) when the supply is used as a constant voltage source and the VOLTAGE controls can be used to establish the voltage limit (ceiling) when the supply is used as a constant current source.

1-3 Two meters measure load current and load voltage at the output terminals of the supply. Protection circuits incorporated in this supply are designed to protect the unit against overload conditions generated by the load device and failures in the input power line, while protection against failures in the internal main power mesh is accomplished by means of the three phase circuit breaker on the front panel. The breaker also serves as the on-off switch for the supply.

1-4 Input power is connected by means of a four-prong lock type connector at the rear of the unit. Output power connections and programming connections for the various modes of operation are also made at rear of the unit. The output terminals consist of heavy bus bar connected directly to the output capacitors for improved high frequency performance.

1-5 The programming terminals located at the rear of the unit allow ease in adapting to the many operational capabilities of the power supply. A brief description of these capabilities is given below:

a. **Remote Programming.** The power supply may be programmed from a remote location by means of an external voltage source or resistance.

b. **Remote Sensing.** The degradation in regulation which would occur at the load because of the voltage drop in the load leads can be reduced by using the power supply in the remote sensing mode of operation.

c. **Series and Auto-Series Operation.** Power supplies may be used in series when a higher output voltage is required in the voltage mode of operation or when greater voltage compliance is required in the constant current mode of operation. Auto-Series operation permits one knob control of the total output voltage from a "master" supply.

d. **Parallel and Auto-Parallel Operation.** The power supply may be operated in parallel with a similar unit when greater output current capability is required. Auto-Parallel operation permits one knob control of the total output current from a "master" supply.

e. **Auto-Tracking.** The power supply may be used as a "master" supply, having control over one (or more) "slave" supplies that furnish various voltages for a system.

1-6 COOLING EQUIPMENT

1-7 The operation of this unit under high load conditions requires that air be circulated through a compartment containing the heat-producing elements in the circuit. This circulation is by means of fans located in the compartment with air flowing from one side of the unit to the other. Maintenance procedures concerning this cooling system will be found in the maintenance section.

1-8 Detailed Specifications for the power supply are given in Table 1-1.

1-9 INSTRUMENT IDENTIFICATION

1-10 Hewlett-Packard power supplies are identified by a three-part serial number tag. The first part is the power supply model number. The second part is the serial number prefix, which consists of a number-letter combination that denotes the date of a significant design change. The number designates the year, and the letter A through L designates the month, January through December respectively. The third part is the power supply serial number.

1-11 If the serial number prefix on your power supply does not agree with the prefix on the title page of this manual, change sheets are included to update the manual. Where applicable, backdating information is given in an appendix at the rear of the manual.

1-12 ORDERING ADDITIONAL MANUALS

1-13 One manual is shipped with each power supply. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and HP stock number provided on the title page.

Table 1-1. Specifications

INPUT:
208/230/460Vac ±10%, 60Hz, three phase. (Instructions are included for wiring for 230 or 208Vac, or unit may be ordered in original purchase contract to be wired for 460Vac.)

OUTPUT: 0-64Vdc, 0-50Adc.

COMBINED LINE AND LOAD REGULATION:
Constant Voltage - Less than 0.2% plus 10mV for a full load to no load change in output current combined with a ±10% change in line voltage.
Constant Current - Less than 1% of $\frac{1}{2}$ amp whichever is greater for a full change in output voltage combined with a ±10% change in line voltage.

RIPPLE AND NOISE:
Less than $\frac{1}{2}$% rms of maximum output voltage for any combination of line voltage, output voltage, and load current.

TRANSIENT RECOVERY TIME:
Less than 50 milliseconds is required for output voltage recovery to within 600 millivolts of the nominal output voltage following a load change from full load to half load or half load to full load.

OPERATING TEMPERATURE RANGE: 0 to 50°C.

TEMPERATURE COEFFICIENT:
Output voltage change per degree Centigrade is less than 0.05% plus 2 millivolts.

STABILITY:
As a constant voltage source the total drift for 8 hours (after 30 minutes warm-up) at a constant ambient is less than 0.25% plus 10 millivolts.

OVERLOAD PROTECTION:
The supply is protected for all overload conditions including a short circuit at the output terminals. This protection is inherent in the constant voltage/constant current automatic crossover operation. The current control acts as a continuously acting limit in constant voltage operation and the voltage control acts as a voltage limit in constant current operation.

AC LINE DROPOUT PROTECTION:
Protection is provided against an input ac line phase dropout. The supply senses the reduction of input voltage, turns off the rectifiers, and opens a power relay which isolates the output power bus. When the input returns to normal, output power is automatically reapplied to the load.

CONTROLS:
A single control makes possible continuous adjustment of the output voltage over the entire range from 0 to 64 volts. The current control knob permits adjustment for maximum output current to the optimum value for protection of the load device. In addition, this latter control serves as the output control for constant current operation. The three phase circuit breaker serves as the ON-OFF control and as secondary protection to the instrument.

METERS:
A 0-80V voltmeter and 0-50A ammeter are provided on the front panel. Internal meter calibration potentiometers are provided.

TERMINALS:
Output power connections are made on two tapped rectangular bus bars located at the rear of the supply. Both power supply output terminals are isolated from the chassis and either the positive or negative terminal may be connected to chassis ground. The upper bus bar is positive.

ERROR SENSING:
Remote error sensing can be accomplished from the rear programming strip.

REMOTE PROGRAMMING:
Remote programming terminals make possible external control of the output voltage or current by resistance programming or voltage programming. Resistance programming in constant voltage is approximately 300-ohms per volt. Resistance programming in constant current is approximately four ohms per ampere.

COOLING:
Internal fans provide forced air cooling of heat producing components.

SIZE:
14" H x 18$\frac{1}{4}$" D x 19" W (standard relay rack mounting).

WEIGHT: 238 lbs. net; 275 lbs. shipping.

FINISH: Light gray front panel with dark gray case.

SECTION II
INSTALLATION

2-1 INITIAL INSPECTION

2-2 Inspect the instrument for signs of damage incurred in shipment. This instrument should be tested as soon as it is received. If it fails to operate properly or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent and this report should be forwarded to your local hp Sales Office (refer to list at rear of manual). The sales office will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument.

2-3 Hewlett-Packard warrants each instrument to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing and adjusting any instrument returned to the factory for that purpose and to replacing any defective parts thereof. Any damage to the instrument upon receipt is due to the carrier. File a claim with the carrier as instructed in the preceding paragraph.

2-4 INCOMING INSPECTION AND PERFORMANCE TEST

2-5 This instrument should be checked as soon as it is received to determine that its electrical characteristics have not been damaged in shipment. Refer to Section V for the performance test.

2-6 LOCATION

2-7 The SCR-3 Series should be mounted securely in a rack. In environments of vibration the rear of the chassis should also be fastened securely. There should be sufficient space along the sides of the instrument to permit free flow of cooling air. This instrument will fit any standard 19 inch rack. If the rack is not accessible from the rear, plug the power cable into the input power receptacle, connect the load leads to the output terminals, and make any changes in the programming terminal strip that may be necessary before sliding the instrument into the rack. (If the rack is accessible from the rear, these connections may be made at any time.) Secure the instrument to the rack with screws and cup washers. Connect the power cable to the power source.

2-8 LINE POWER

2-9 Because of the variety of line power connectors for three phase power sources, a power cord is not supplied but a twist lock type of connector that mates to the input power receptacle on the unit will be shipped with each new unit. The power cord and the plug for connection to the power source will be supplied by the buyer. Input line current is 15A maximum for a 208Vac line, dictating each conductor be at least number 14 gauge wire.

2-10 The ac power source to this supply may be either delta or wye with isolated neutral.

2-11 The SCR-3 Series as shipped, are wired for 230 volts ac ±10%, three phase, 60Hz. 208Vac ±10%, three phase, 60Hz may be accommodated by changing the strapping configuration on the input transformer. Refer to Section V for details on this change. The unit can be wired by the factory for 208Vac, or 460Vac ±10% 60Hz, when specifically requested by the buyer in his original purchase contract.

2-12 REPACKAGING FOR SHIPMENT

2-13 The best method of packing the instrument is in the original shipping carton with the original fillers packed in the same manner as received from the factory. Therefore, when unpacking note carefully the method of packing and save the original packing material for possible future reuse.

2-14 If the original packing material is not available and it is desired to pack the instrument for storage or shipment, first wrap the instrument in heavy kraft paper to avoid scratching the paint, then pack the instrument in a cardboard carton with a bursting strength of at least 150 pounds per square inch. Pad the instrument on all sides with at least two inches of rubberized hair. Enclose the cardboard carton in a floating base type wooden carton and strap the carton securely to the base. Provide at least two inches of rubberized hair around the four sides of the box and between the box and the top of the crate.

2-15 STORAGE

2-16 No special precautions are necessary in storage of this unit except the usual protection against mechanical damage, salt air, etc.

SECTION III
OPERATING INSTRUCTIONS

3-1 PRELIMINARY CONSIDERATIONS

3-2 Check the strapping pattern on the rear terminals for the proper connection of the rear. **Make sure that all binding head machine screws on the rear barrier strip are tight. Many troubles can arise if these straps are not making connection.** Determine the type of operation as shown in Figures 3-1 through 3-12 and make certain that the rear barrier strip straps are connected for the operation desired. The power supply as furnished from the factory has a strapping arrangement as shown in Figure 3-1.

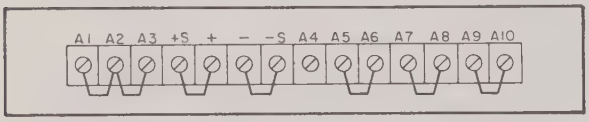


Figure 3-1. Normal Strapping Pattern

3-3 CONNECTIONS TO LOAD

3-4 Load is applied to rectangular bus bars at the rear. The upper bus is positive.

3-5 Sensing is accomplished at rear terminals of the power supply as shipped from the factory. The user should be cognizant of the voltage drop which will occur in load leads, and minimize the drop by using large size cable and minimizing the lead length to the load. Regulation at the load can be maintained within the specifications of the power supply by using remote sensing as described in this section of the manual.

3-6 CONSTANT CURRENT

3-7 The constant current circuit in the SCR-3 series serves two purposes. It protects the power supply and load, and it allows the supply to act as a constant current power source. If only a coarse current limit is required, the current control knob can be set somewhat above the point at which the supply will switch into constant current operation and be controlled by the current knob. In instances where the current limit need be set more precisely, the following procedure should be followed:

a. Turn the VOLTAGE and CURRENT controls full counterclockwise.

b. Place a short circuit across the output terminals of the supply.

c. Slowly rotate the VOLTAGE control clockwise about one-half turn.

d. Bring up the CURRENT control until the output current as read on the front panel meter reads the desired value of current.

e. Rotate the VOLTAGE control counterclockwise, remove the short circuit, reapply the normal load, and adjust the output voltage to the desired setting.

3-8 When operating in the constant current mode, the voltage control can be adjusted for overvoltage protection.

3-9 REMOTE SENSING (See Figure 3-2)

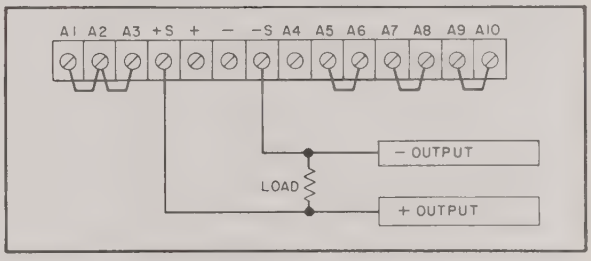


Figure 3-2. Remote Sensing

3-10 In cases where the load device is remote from the power supply, resulting in poor load regulation at the load terminals, remote sensing can be used. As shipped, the power supply senses the output voltage at the output terminals of the supply and any IR drop in the leads between the power supply and the load causes a consequent degradation of the regulation at the load terminals. By sensing the output voltage at the load device terminals, these IR drops are effectively eliminated. The procedure for sensing the load at a remote location is as follows:

a. Turn off the front panel circuit breaker and remove the power cord from the power source.

b. On the barrier terminal strip on the rear of the unit remove jumpers (+S to +) and (-S to -).

c. Connect a pair of leads (#20 gauge wire) between +S and the positive terminal of the remote load and between the -S terminal of the supply and the negative terminal of the remote load.

d. Reconnect the ac power and turn on the power supply.

NOTE

The maximum IR drop that can be contained in the negative bus by means of remote sensing is one volt.

3-11 Although the use of remote sensing improves the dc load regulation at the load, it is important to note that the ac impedance at the load terminals is no better than it was with local sensing. In order to bring about an improvement in the ac impedance, it is advisable to place a large electrolytic capacitor across the terminals of the remote load.

3-12 REMOTE PROGRAMMING-CONSTANT VOLTAGE

3-13 The power supply may be programmed from a remote location by means of an external resistance or an external voltage. It is necessary to change the strapping pattern on the barrier strip at the rear.

3-14 Resistance Programming (See Figure 3-3).

a. A stable, low noise, low temperature coefficient programming resistor is recommended.

b. The programming resistor takes the place of the front panel potentiometer.

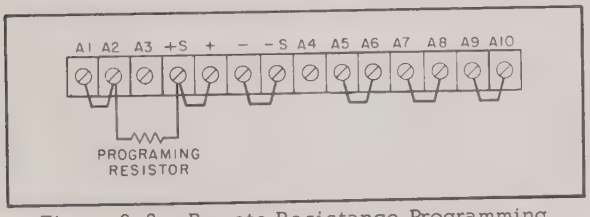


Figure 3-3. Remote Resistance Programming (Constant Voltage)

c. The output voltage will vary at a rate determined by the programming coefficient - 200 ohms per volt (i.e., the output voltage will vary 1 volt for each 200 ohms connected across the programming terminals). The programming coefficient is determined by the programming current. The current is adjusted to within 0.5% of 5.0 milliamperes at the factory. If greater programming accuracy is required, it may be achieved by changing the shunt resistor, R8.

3-15 Voltage Programming (See Figure 3-4).

a. A stable, low noise, low temperature coefficient programming resistor is recommended.

b. R_f = 1.2K. Resistor Rp need not be used if the front panel C.V. potentiometer is left connected and set as follows:

Model	6450A	6453A	6456B	6459A
Rp	1.6K	3K	6.8K	1.2K

c. The output voltage will vary linearly as

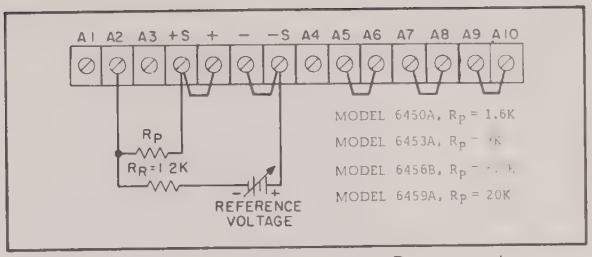

A1 A2 A3 +S + − −S A4 A5 A6 A7 A8 A9 A10
Rp
RR=1.2K
REFERENCE VOLTAGE
MODEL 6450A, Rp = 1.6K
MODEL 6453A, Rp = 3K
MODEL 6456B, Rp = 6.8K
MODEL 6459A, Rp = 20K

Figure 3-4. Remote Voltage Programming (Constant Voltage)

the reference voltage is changed.

d. The reference voltage in going from zero to -6 volts will change the supply output voltage from zero to the maximum rated output voltage. The maximum load on the reference voltage will be 5mA.

3-16 REMOTE PROGRAMMING-CONSTANT CURRENT

3-17 The power supply may be programmed from a remote location by means of an external resistance or an external voltage. It is necessary to change the strapping pattern on the barrier strip at the rear.

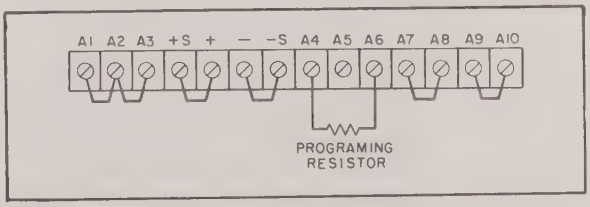


Figure 3-5. Remote Resistance Programming (Constant Current)

3-18 Resistance Programming (See Figure 3-5).

a. A stable, low noise, low temperature coefficient programming resistor is recommended.

b. The programming resistor takes the place of the front panel potentiometer.

c. The output current will vary at a rate determined by the programming coefficient-approximately two ohms per ampere (i.e., the output current will vary one amp for each two ohms connected across the programming terminals). The programming coefficient is determined by the programming current. As a protection feature, the actual programming current has been set by the factory by turning the front panel current control potentiometer (250A) full cw and adjusting shunt R22 for a maximum current limit of 10% over the maximum rated output current. This ratio, taking into account the offset voltage of the constant current differential amplifier, sets the coefficient at approximately two ohms per amp. If greater programming accuracy is required, it may be achieved by reshunting R22 terminals.

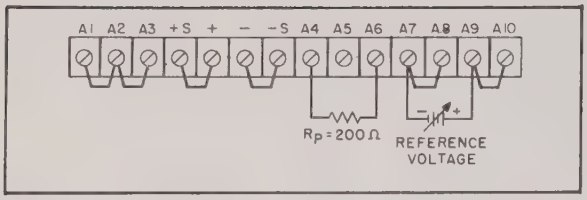


Figure 3-6. Remote Voltage Programming (Constant Current)

3-19 Voltage Programming (See Figure 3-6).

a. A stable, low noise, low temperature coefficient programming resistor is recommended.

b. Rp = 200 ohms or this resistor need not be used if the front panel current potentiometer is left connected and set maximum cw.

c. The output current will vary linearly as the reference voltage is changed.

d. For Rp = 200 ohms; the reference voltage in going from zero to +6 volts will change the supply output current from zero to the maximum rated output current. The maximum load on the reference voltage will be 1.8 milliamperes.

3-20 AUTO-SERIES

3-21 For higher voltages, two or more SCR-3's may be stacked with the positive bus of one tied to the negative bus of the next. Control of all supplies by a single voltage control is enabled by the addition of one control lead, as shown in Figure 3-7.

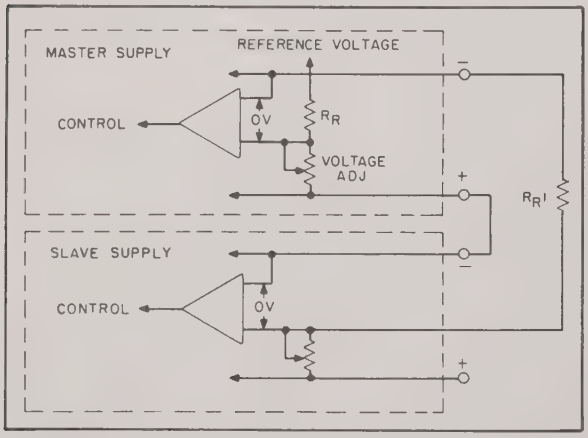


Figure 3-7. Auto-Series Schematic Diagram

With this connection, the "master" supply becomes the reference voltage for the others, which have had their internal voltage references disconnected (a new fixed resistor is added). The slave supplies, set individually to any voltage, will track the master voltage proportionally.

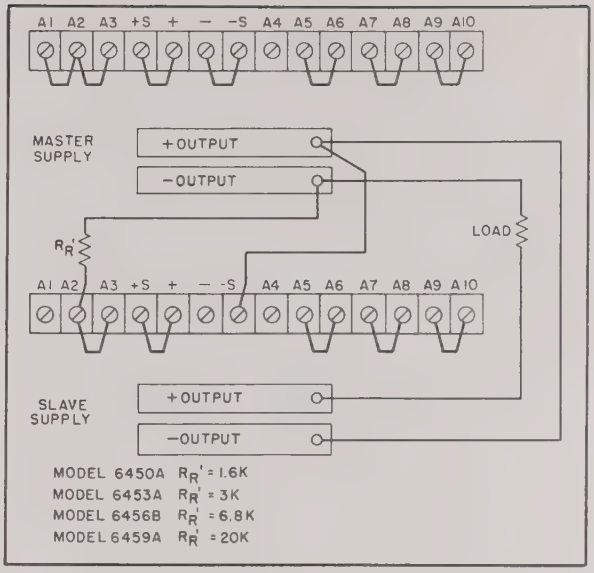

A1 A2 A3 +S + − −S A4 A5 A6 A7 A8 A9 A10
MASTER SUPPLY
+OUTPUT
−OUTPUT
LOAD
RR'
A1 A2 A3 +S + − -S A4 A5 A6 A7 A8 A9 A10
SLAVE SUPPLY
+OUTPUT
−OUTPUT
MODEL 6450A RR' = 1.6K
MODEL 6453A RR' = 3K
MODEL 6456B RR' = 6.8K
MODEL 6459A RR' = 20K

Figure 3-8. Auto-Series Connection Diagram

3-22 Wiring instructions for the connection of two supplies are illustrated in Figure 3-8. The VOLTAGE control of the slave must be set off zero at all times.

3-23 Where one load is connected across the output of series connected units (either end of the ensemble grounded), the current limit of the master should be used to control the current limit point of the ensemble. With the configuration providing dual voltages to independent loads, each unit has its own current limit point as programmed at the front panel CURRENT control but the output voltage of the slave will be proportional to the master output voltage.

3-24 The load regulation and line regulation characteristics of two or more supplies connected in series will be approximately the sum of the figures for each unit in the ensemble. Transient response should be approximately that of a single unit (50 milliseconds for a change in load from one half to full load).

3-25 AUTO-PARALLEL

3-26 Two or more power supplies may be connected in parallel for higher load current requirements with control of the output voltage and current retained in one of the units (master). In this configuration the maximum current capabilities of the ensemble is within 10% of the sum of the maximum current capabilities of the units so connected. The constant current differential amplifiers of the slave supplies are disconnected from their own references and re-

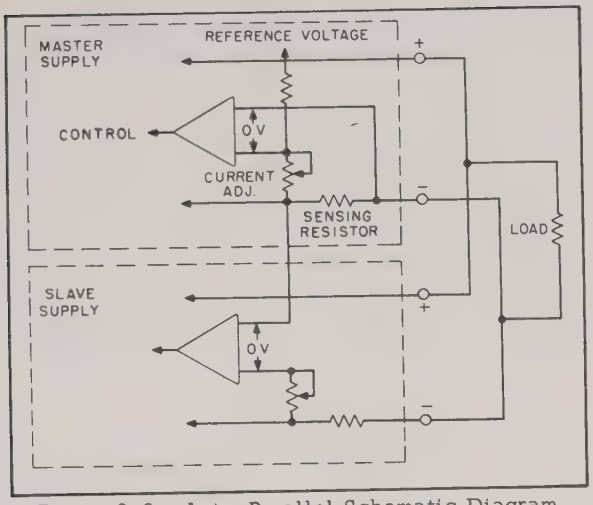


Figure 3-9. Auto-Parallel Schematic Diagram

connected as shown in Figure 3-9. Each slave differential amplifier adjusts its current output so the voltage drop across its current monitoring resistor matches that across the current monitoring resistor of the master supply. Wiring instructions for the connection of two supplies are illustrated in Figure 3-10.

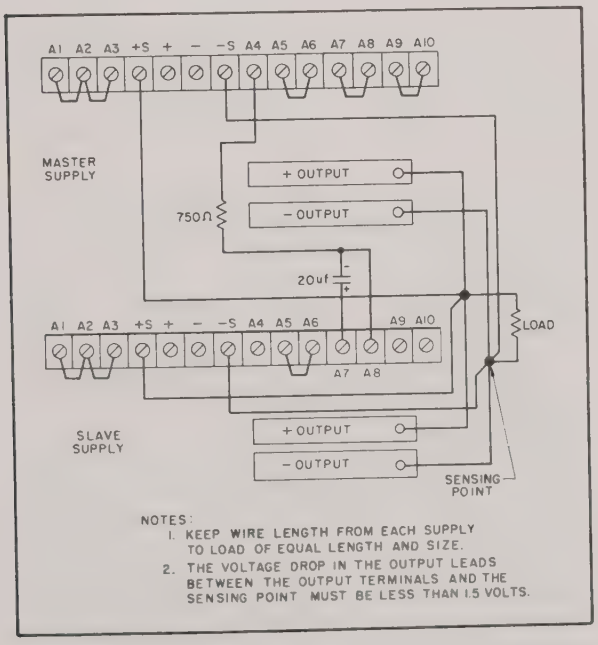

A1 A2 A3 +S + − −S A4 A5 A6 A7 A8 A9 A10
MASTER SUPPLY
+ OUTPUT
750Ω
− OUTPUT
20uf
LOAD
A1 A2 A3 +S + − −S A4 A5 A6 A9 A10
A7 A8
SLAVE SUPPLY
+ OUTPUT
− OUTPUT
SENSING POINT
NOTES:
1. KEEP WIRE LENGTH FROM EACH SUPPLY TO LOAD OF EQUAL LENGTH AND SIZE.
2. THE VOLTAGE DROP IN THE OUTPUT LEADS BETWEEN THE OUTPUT TERMINALS AND THE SENSING POINT MUST BE LESS THAN 1.5 VOLTS.

Figure 3-10. Auto-Parallel Connection Diagram

3-27 BATTERY CHARGING

3-28 The automatic transition between constant voltage and constant current displayed by the SCR-3 Series makes it an ideal supply for battery charging applications. Using this feature, a battery may be charged at a constant current until the maximum charge voltage is reached at which point the supply will revert to constant voltage and continue to supply a trickle charge current sufficient to maintain full charge (see Figure 3-11). Thus, the charging operation can be unattended after properly setting the charging rate and the maximum charge voltage and connecting the battery to the output terminals of the supply.

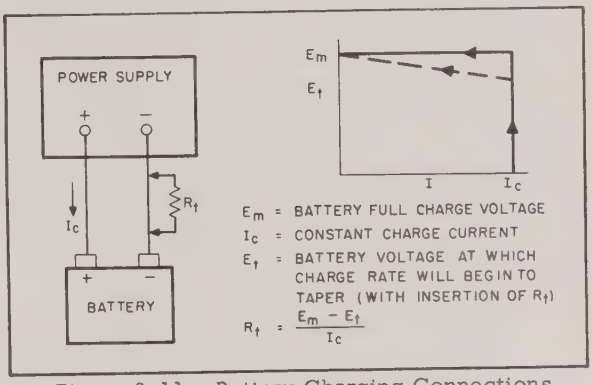


Figure 3-11. Battery Charging Connections

3-29 The procedure for setting the charging rate and full charge voltage on the SCR-3 Series is as follows:

a. Turn both the VOLTAGE and CURRENT controls fully counterclockwise.

b. Place a short circuit across the output terminals and rotate the VOLTAGE control one half turn clockwise.

c. Rotate the CURRENT control to the desired charging rate as read on the front panel ammeter.

d. Rotate the VOLTAGE control fully counterclockwise and remove the short circuit.

e. Rotate the VOLTAGE control to the desired full charge voltage as read on either the front panel voltmeter or a more precise voltage standard. The unit may then be connected to the battery terminals, positive to positive and negative to negative.

3-30 By inserting a small resistance in series with one of the load leads from the supply to the battery, it is possible to alter the normally rectangular charging plot (Figure 3-12) in such a manner as to provide a taper charge for the last portion of the charge cycle. The value of this resistance is the difference between the full charge voltage and the voltage at which the tapering is to start, divided by the maximum charging current.

3-31 A large battery connected across the supply, presents a very large capacitance at the output. This can cause oscillation in the feedback loop; particularly if remote sensing is employed. To stabilize the feedback loop, adjust potentiometer R10

so as to increase its resistance. If this does not suffice, a resistance must be inserted in series with R10. Further details concerning battery charging applications can be obtained by contacting the factory.

3-32 BATTERY DISCHARGING

3-33 Automatic constant current, unattended discharging of a battery using the SCR-3 Series requires certain changes in the strapping configuration on the rear barrier strip as illustrated in Figure 3-12.

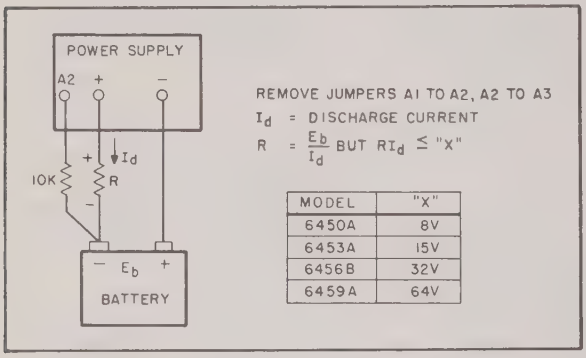


Figure 3-12. Battery Discharging Connections

These changes are the removal of the jumpers from A1 to A2 and from A2 to A3 and the connection of A2 to the negative terminal of the battery through a 10K resistor. Make sure that the interconnecting leads between supply and battery are secure and cannot become opened.

3-34 The supply initially operates in constant current mode at the value set by the current control. When the battery voltage is high the supply output voltage will be low, and as the battery discharges the supply output voltage increases. A constant voltage is maintained across R (constant current through R). This condition will prevail until the battery voltage drops to zero. At this point, the supply will switch off and no more current will flow through R.

3-35 The procedure for the connection of the components in this configuration is as follows:

a. De-energize the power supply and rotate the current control fully counterclockwise. (The voltage control will be disconnected by step b.)

b. Remove the designated jumpers (A1 to A2, A2 to A3) and connect A2 to the negative terminal of the battery.

c. Connect the negative terminal of the supply to the positive terminal of the battery.

d. Insert R between the positive terminal of the supply and the negative terminal of the battery, energize the supply and rotate the current control to the desired discharge current as read on the front panel meter.

3-36 MULTIPLE LOADING OF A POWER SUPPLY

3-37 It is imperative that each load have two separate leads brought directly back to the power supply terminal when connecting several pieces of equipment or subassemblies to the same power supply if full advantage is to be taken of the low impedance of the supply and mutual coupling effects between the equipment being powered are to be avoided.

3-38 AUTOMATIC CROSSOVER

3-39 There will be a time during which both the constant voltage input transistor and the constant current input transistor will be conducting. This will occur when the power supply has been operating in the constant voltage mode of operation and is overloaded or when the power supply has been operating in the constant current mode and the load is changed so that the output voltage reaches the voltage ceiling threshold. When operating in this crossover region, the regulation of the principal mode can be degraded. To prevent this, the control should be set to provide a margin of operation.

3-40 The current threshold should be greater than the maximum load current when operating in the constant voltage mode of operation as follows:

Model	6450A	6453A	6456B	6459A
Amperes	25	15	10	5

3-41 The voltage threshold (open circuit voltage) should be greater than the maximum operating output voltage when operating in the constant current mode of operation as follows:

Model	6450A	6453A	6456B	6459A
Volts	0.5	1	2	4

3-42 MEASURING THE PERFORMANCE OF THE POWER SUPPLY

3-43 The measuring device (differential voltmeter, digital voltmeter, or oscilloscope) must be connected to the output terminals as close as possible to the supply when measuring the output impedance, transient response, regulation, or ripple of the power supply in order to achieve valid measurements. It is important that none of the output current flows through the lead lengths in series with the monitoring device since such lead lengths can easily have an impedance of the same order of magnitude as the supply impedance and thus effectively invalidate the measurement.

3-44 Connect either the positive or negative terminal of the supply to the chassis ground and the scope case to the same point, making certain that the scope case is not also grounded by some other means such as the power cord when measuring the power supply ripple. Connect both scope leads simultaneously to the power supply ground terminal to be doubly certain that the scope is not exhibiting a ripple or transient spike that is not coming from the power supply.

3-45 It is recommended that a four-terminal resistor be used to make constant current measurements.

SECTION IV
PRINCIPLES OF OPERATION

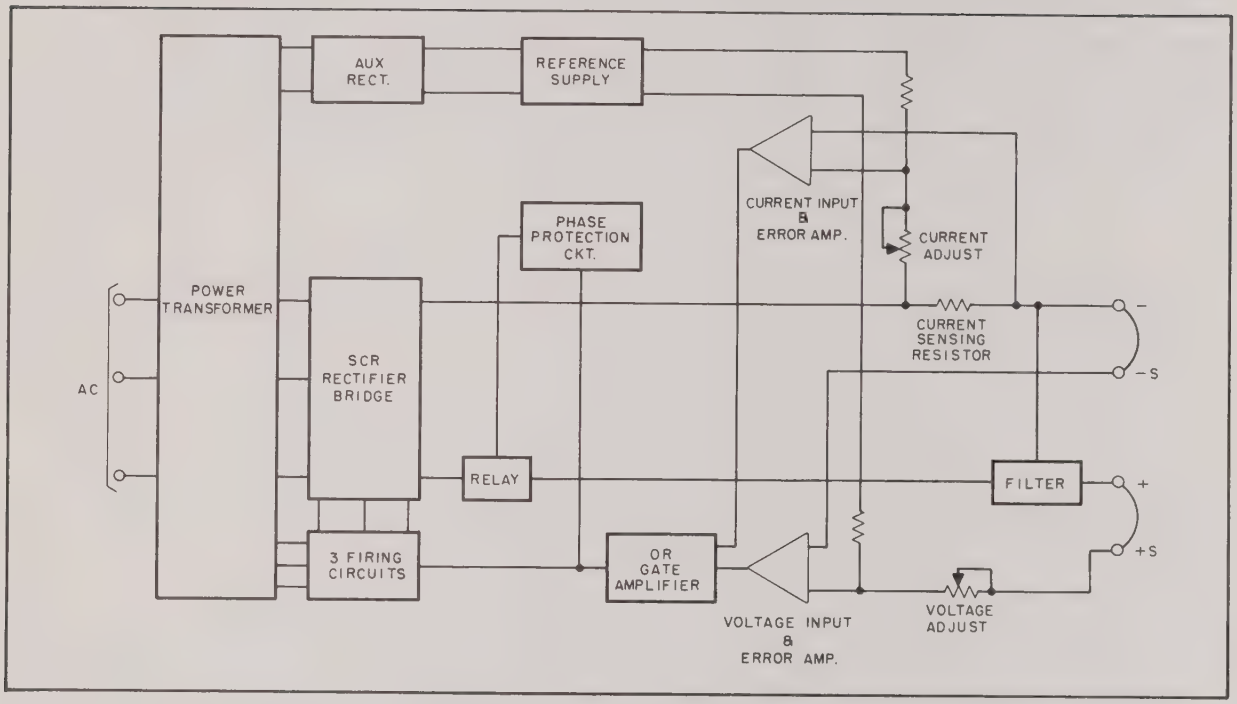


Figure 4-1. Overall Block Diagram

4-1 BLOCK DIAGRAM

4-2 The block diagram, Figure 4-1, shows the basic parts of the power supply. The line voltage is transformed by the three phase power transformer to the bridge rectifier circuit containing both fixed rectifiers and silicon-controlled rectifiers. The SCR turn-on firings are controlled in such a manner as to supply the desired output voltage and current. Separate windings on the power transformer furnish three phase voltage to the auxiliary rectifier for the bias supply and furnish three phase voltage for the three firing circuits to operate on.

4-3 The dc current passes through the current sensing resistor connected in the negative bus. The voltage developed across the sensing resistor is the input to the current input amplifier. The output voltage of the power supply is monitored by the voltage input amplifier through the sensing terminals (+S and -S). Any changes in output voltage/current are detected in the constant voltage/current input amplifier, passed through the "OR" gate, and applied to the firing circuits. The firing circuits control the SCR firing to counteract the change.

4-4 The "OR" gate implements the constant voltage/constant current crossover operation of the supply. It allows one or the other amplifier signal to pass and control the loop but not both at once. The more restrictive signal, demanding less power output, is the controlling signal.

4-5 SIMPLIFIED SCHEMATIC

4-6 The simplified schematic, Figure 4-2, shows the various voltages used throughout the supply. The ammeter location, across the current sensing resistor R96, and the voltmeter location, across the output terminals of the power supply are shown. C12-C17, across the output, are the filter capacitors and, together with choke L1, form the power filter. CR10 is a (F.W.D.) free wheeling diode acting in conjunction with the choke. Also, it protects the power supply if a reverse voltage is applied across the output terminals.

4-7 R97, R98, and CR61 function as a voltage ceiling circuit. When the output voltage at the positive terminal reaches the ceiling level, CR61 turns on, introducing a positive hold signal to the

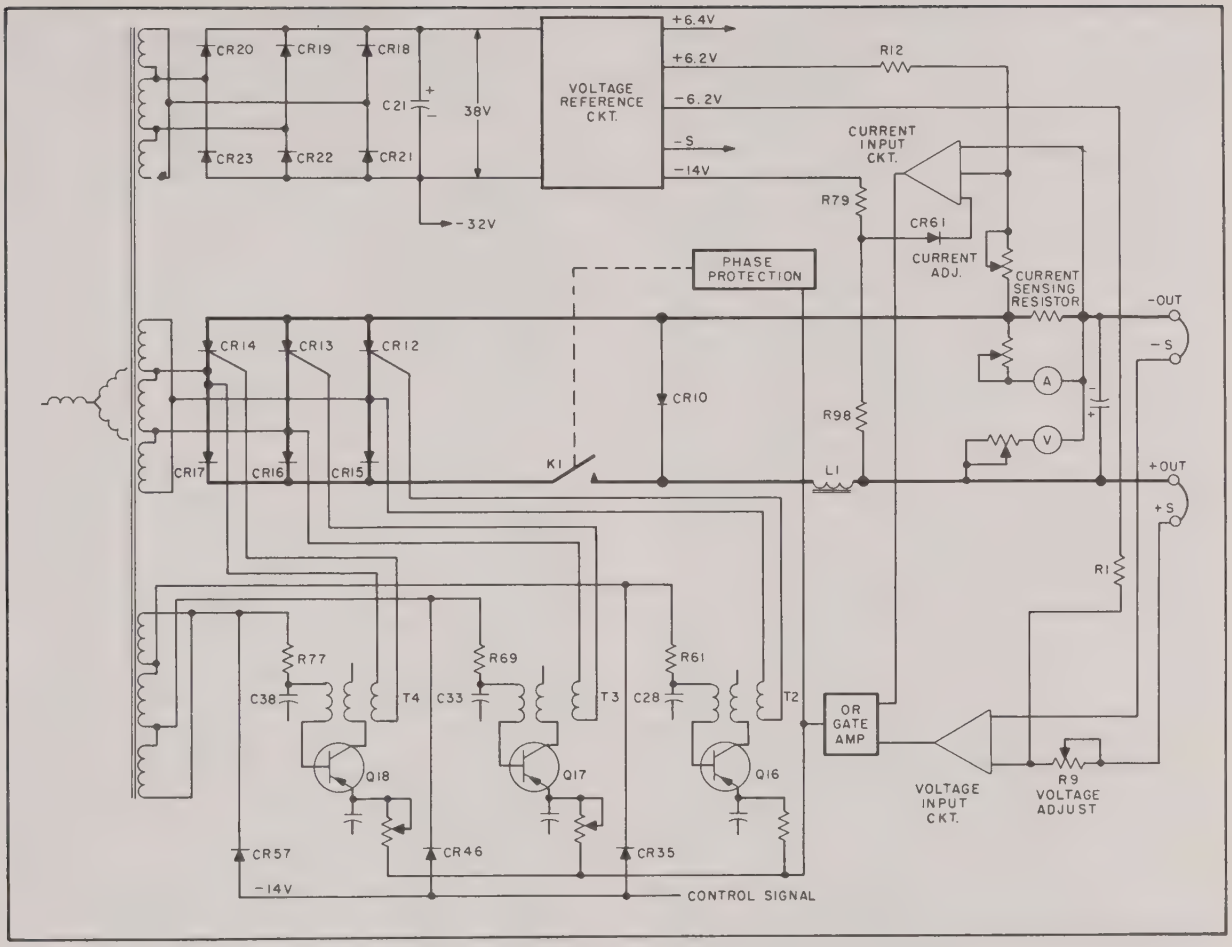


Figure 4-2. Simplified Schematic

current input amplifier. Another protection feature is the phase protection circuit which stops operation if an input ac line phase opens or the line voltage drops below normal. The circuit samples the three input phases (from three diodes not shown in the simplified schematic) and in the event of failure turns off the control signal to the firing circuits and then opens power relay K1. When the input returns to normal, the relay is closed and firing pulses resume.

4-8 The function of the constant voltage input differential amplifier is to compare the reference voltage with the output voltage and to generate a correction signal if the output deviates from its prescribed value. One input to the amplifier is grounded to the negative output terminal -S while the other input is the summing point of output voltage and the -6.2Vdc reference voltage. When no error exists zero volts is maintained between the amplifier input terminals. Any change in output voltage, whether it is due to a change in the setting of the front panel potentiometer or perhaps due to a change in load current tends to produce a voltage other than zero at this second input terminal. Feedback loop action thereafter is such as to reduce this error to zero.

4-9 The action of the constant current input amplifier is similar to the constant voltage amplifier. The current sensing resistor, which monitors the output current, is a strip resistor located in the air blast alongside the main heat sink. Four terminal connections are made to it, one sensing terminal constituting the reference for the constant current loop, the other the signal terminal going to the amplifier.

4-10 The three firing circuits receive the output of the OR-gate amplifier, mix this with an ac bias provided by the bias transformer windings, (this allows instantaneous correction for changes in line voltage) and generate firing pulses that turn on the silicon-controlled rectifiers in their respective phases at the precise time necessary to fulfill the feedback loop requirements. As can be seen in

Figure 4-2, everything is done in triplicate. For each phase there is a transistor blocking oscillator with the third winding of the blocking oscillator transformer providing the gate pulse to the SCR gate leads. The three bias transformer windings are delta connected and the leads brought out to diodes CR35, CR46, and CR57. These diodes perform half wave rectification of the ac voltage. Thus, the voltage waveforms to input resistors R61, R69, and R77 are the same phase and shape as the waveforms across the SCR's in the main rectifying bridge.

4-11 MAIN RECTIFYING AND FILTERING CIRCUITS (See schematic at rear of manual)

4-12 Three phase 230Vac, 60Hz line voltage is connected to the primary of transformer T1 through a three phase common trip type circuit breaker which serves the dual function of ON/OFF control and protection against failure in the main power mesh. The wiring on the primary of the transformer may be changed to accommodate three phase 208Vac, or 460Vac as outlined in the maintenance section. The primary is Wye connected with isolated neutral. The 208Vac taps to neutral are used to power the fans and the front panel power indicator light. The three main secondary windings are delta connected to a three phase fullwave bridge consisting of three SCR's (CR12,13,14) and three fixed rectifiers (CR15, 16,17). The positive dc output side is the rectifier heat sink. The heat sink is cabled to the relay, then choke, and then to the filter capacitor bank + (C12-C17). The negative dc output side is the SCR heat sink. The sensing resistor is located on the heat sink as its output terminal, and from it cabling connects to -(C12-17). The firing angle of each SCR is controlled in such a manner as to fulfill the load conditions on the output terminals of the supply dictated by the output voltage/current setting and the load resistor. Resistor R60 provides a bleed path for the discharge of the filter capacitors at no load.

4-13 CR10 is the free wheeling diode (F.W.D.) rectifier. It has a reverse polarity rectifier case and is located in the SCR heat sink so its cathode can be connected after the relay on the positive output.

WARNING

Make sure replacement for CR10 is a **reverse polarity** rectifier.

4-14 The F.W.D. conducts, carrying the choke current, for the parts of each cycle when no SCR is conducting, and therefore conducts under every condition except full power output. Due to the action of choke and F.W.D., the SCR conduction angle, at short circuit full current output, is small and the input acrms line current is approximately one half that at full power. Also, CR10 protects the output capacitors in case a reverse voltage is applied on the output terminals. (Such a case can occur in auto-series operation when the slave unit is de-energized while the master unit is energized.)

4-15 REFERENCE CIRCUIT (See schematic at rear of manual)

4-16 Three phase fullwave bridge windings 3, 4 on transformer T1 provide power for the auxiliary and reference voltages. Diodes CR18 through CR23 and capacitor C21 provide an unregulated -32Vdc (test point 20). All voltages are measured with respect to -S. The positive side of this unregulated auxiliary voltage is returned to +6.4Vdc.

4-17 Resistors R49, R50, R51, Zener diode VR3 and transistor Q14 form a shunt regulator whose output is a -14Vdc (T.P.12). In this configuration resistor R49 provides a constant bias current for VR3 (a 20 volt zener diode). Any voltage variation across the shunt regulator is transmitted via the low impedance of VR3 to the base of the transistor. Q14 changes its collector current which is reflected in a voltage change across R51, reducing the variation. R50 reduces the power dissipation of Q14. C20 reduces ripple and causes a slow buildup of the -14 volts at turn-on. The line regulation of this -14 volt source is approximately ±100 millivolts for an input line change of ±10%.

4-18 R48, two 6.2 volt zener diodes VR1 and VR2, and Q13 are connected in series from -14Vdc to +6.4Vdc. VR1 and VR2 produce the two reference voltages +6.2Vdc and -6.2Vdc. Any changes in the -14Vdc source are attenuated by the ratio of R48 to the forward impedance of the two diodes in series. Q13 acts as a shunt regulator for VR1, the base to emitter voltage and R47 determing the zener bias current. There is a large variation in the current returning through +6.4Vdc to -S from other parts of the circuit and this bypasses VR1 through Q13.

4-19 CONSTANT VOLTAGE INPUT AMPLIFIER (See schematic at rear of manual)

4-20 Transistors Q1 and Q2 form a differential amplifier for the purpose of error detection and amplification in the voltage mode. The inputs of this amplifier are the bases of the two transistors. The output is the collector of Q1. The base of Q2 is considered the reference base and is connected to -S through R5 to achieve good thermal compensation. R6, from the base to the -6.2Vdc reference voltage, provides a slight negative bias voltage at the base to insure that the output of the power supply is adjustable to zero volts. The base of Q1 is connected to summing point A2, which is the junction of current pullout resistor R1 and the front

panel potentiometer R9. The control action continuously adjusts the output voltage on the positive bus to bring the voltage at A2 to the -S potential. With A2 held at the -S bus voltage, the voltage drop drop across R1 is the same as the reference voltage, and this voltage drop remains constant during operation. The current through R1, and thus through R9, likewise is held constant so that the IR voltage drop across R9 is determined solely by the resistance value of R9. Thus, the power supply output voltage is a linear function of the resistance of R9.

4-21 R2 in the base lead of Q1 limits the current through the programming resistance (pot) under conditions of rapid voltage turndown, and also isolates input and base for stabilizing the feedback loop. Diodes CR1 and CR2 limit voltage excursions on the base of Q1. Capacitor C1 bypasses the pot making the high frequency gain of the input circuit insensitive to pot setting. Capacitor C2 and adjustment pot R10 are located around the amplifier for loop stability.

4-22 CONSTANT CURRENT INPUT AMPLIFIER

4-23 Transistors Q4 and Q5 form a differential amplifier for the purpose of error detection and amplification in the current mode. The basic operation is the same as the constant voltage input amplifier. However, in the current case reference is with respect to the sensing terminal A7 of the sensing resistor R96. R20 at the base of Q5 is normally connected to this reference. The resistor R96 requires four terminals to keep the voltage drop along the internal connections of the power supply from the sensing resistor to (-) from contributing to the input signal. The following components of the constant current input amplifier have functions as described for the voltage input amplifier:

R19 - Positive offset bias to base of Q5.
CR5,CR6 - Protection diodes.
R13 - Current limiting.
C5 - Stability.
R24 - Stability adjustment.
R23 - Front panel current control pot.
R12 - Current pullout resistor; sets programming current.
R22 - Shunts R12; used for trimming adjustment.

4-24 Additional components are C4, CR4, and R14, and those associated with Q6. C4 reduces ripple voltage entering the amplifier. CR4 and R14 come from the Phase Protection Cutoff Circuit. Normally, the cathode of CR4 is +5.5Vdc so the diode is cut off. Upon a phase failure, however, the voltage drops to approximately -28Vdc at R14, CR4 turns on, and CR6 is clamped on by the 1mA current. This negative signal shunts the supply off via the constant current loop. Q6 supplies 1mA bias collector current to Q5 without shunting down the 47K load resistor R18. In this way, the dc gain of the constant current loop is increased. The bias current is fixed by the ratio of the forward voltage drop of CR7 and R17.

4-25 "OR" GATE AMPLIFIER (See schematic at rear of manual)

4-26 The OR gate receives signals from the two input amplifiers at the bases of Q8 and Q9. The most negative base signal tends to turn its transistor on harder. At the same time, the negative voltage is transmitted to the emitter and so to the emitter of the other transistor, turning it off. When the signal to either input amplifier increases above the level set by the control pot, the amplifier output moves negatively. This switches the OR gate and that amplifier controls the loop at its voltage/current setting.

4-27 The output of Q8/Q9 is amplified by Q10 to a suitable voltage level for controlling the firing circuits (T. P. 15):

Power supply OFF signal: Q10 saturated, -13Vdc
Power supply just ON: -10Vdc
Maximum power: +2Vdc

4-28 Diode CR9 at the emitter of Q10 provides 0.7Vdc bias voltage for the stage. Q11 is an emitter follower which transforms impedance so the firing circuit is driven from a voltage source.

4-29 An auxiliary feedback signal is connected from the input side of choke L1 (T. P. 14) to the base of Q10 via R28 and C8. Capacitor C9, to reference A7, performs three functions:

1. C9 reduces ripple appearing from the input L1;
2. C9 provides a frequency cutoff slope;
3. C9 causes a slow turn-on signal buildup to the firing circuits.

4-30 SILICON-CONTROLLED RECTIFIER FIRING CIRCUITS (See schematic at rear of manual)

4-31 GENERAL

4-32 The SCR is a solid state device which displays high impedance characteristics with either positive or negative voltage on its anode but which may be switched into a high conductance state when positive voltage is supplied to the anode simultaneously with a gate signal application between its gate lead and its cathode. The gate signal that is used to turn on the device in the SCR-3 Series is a positive going pulse of about 50μsec duration and whose amplitude is approximately 3.5 volts, this being the output of the blocking oscillator.

4-33 Each of the input phases has an SCR and a firing circuit associated with it. Each firing circuit generates an output pulse for its SCR once each cycle of input line frequency and so timed that each SCR conducts at identically the same phase angle in its respective phase.

4-34 The input to the three firing circuits is the output of the OR gate amplifier (transistor Q11 emitter) and is as previously mentioned a dc voltage referenced to -S and varying in amplitude between +2 volts and -10 volts as a function of the output conditions. This voltage is applied to three identical ramp capacitors (C26,C31,C36) through resistances R60,R87,R68,R76, and R88. The relatively high voltage signal produces current in each resistor which is integrated by the ramp capacitors to produce a steadily rising ramp voltage. R87 and R88 are pots which are adjusted to balance or nearly balance the ripple voltage on the output of the power supply.

4-35 BLOCKING OSCILLATOR

4-36 A blocking oscillator is the firing circuit for each phase in the SCR-3 Series. The blocking oscillators (T2,T3, and T4) are triggered into the conducting state by a transistor. Each output winding of the transformers (terminals 11 and 12--TP25,26, 30,31,35,36) is connected between the gate and cathode leads of an SCR through a series current limiting resistor (R56,R64, and R72) with a diode connected in the reverse direction between gate and cathode of the SCR to prevent the possible appearance of a reverse spike or pulse on the gate of the SCR (CR26,CR37, and CR48).

4-37 The mechanism by which the blocking oscillator is triggered is by switching the transistor from the non-conducting state into the conducting state (transistor Q16-18). The transistor has as its collector load one winding of the blocking oscillator transformer. Two windings are connected in series (for double voltage) in the base lead of the transistor. The base of the transistor follows the voltage of the base capacitor (C28,C33, and C38). The voltage on the emitter rises to meet the base at which time blocking oscillator action takes place. The start of current in the emitter of the transistor and the regenerative coupling that exists between the collector and base windings causes the transistor to go into saturation where it remains until the saturation region of the transformer is reached. At this point the coupling action collapses and the transistor returns to the non-conducting state.

4-38 Capacitors C25,C30, and C35 between the base and emitter prevent spurious triggering. Resistors R59,R67, and R75 in the base circuits limit the base current which flows during the blocking oscillator action. Upon conduction of the blocking oscillators, the ramp capacitors discharge negative with the emitter current and the base capacitors charge positive with base current. This prevents the blocking oscillator circuit from retriggering during that same cycle. At the end of the cycle these capacitors are reset for the next cycle.

4-39 FIRING ANGLE DETERMINATION

4-40 Determination of the proper firing angle is accomplished by mixing two signals in the blocking oscillator circuit, these two signals being a reflection of the output conditions and the input line conditions. A ramp voltage whose origin is approximately -17Vdc and whose slope is a function of output voltage and output current is subtracted from a halfwave rectified voltage whose amplitude is a function of the input line voltage.

4-41 The three phase bridge circuit providing voltage to the firing circuits consists of windings 5, 6 on the main transformer and diodes CR35,CR46, and CR57. This bridge provides the waveshape shown in Figure 4-3 to the firing circuits through R64,R69, and R77. R78 reduces the amplitude of the signal from R77 and C38 charges toward the positive peak. The integrating action of C38, along with diode CR55, provides a smooth voltage shape at C39 with the amplitude still a function of line voltage.

4-42 Line Compensation. If the input ac line voltage increases from nominal the voltage wave amplitude at C38, the base of Q18, increases. Then more time is taken for the ramp at the emitter to catch the base voltage and SCR firing is delayed. The decreased firing conduction angle compensates for the larger voltage available at the input.

4-43 RESET OPERATION

4-44 At the end of each line cycle the ramp capacitor and base capacitor are reset to their starting voltages and operation repeats. The resetting operation is performed by the positive going rectified wave referenced to -14Vdc (see Figure 4-3), which is the input to the firing circuits at CR35,CR46, and CR57. These diodes with anode at -14Vdc set the reference level by clamping. Diodes CR49-51, and CR54 are always conducting; their bias current flows to the -32Vdc through R73. Thus, the voltage at the cathodes of CR52 and 53 follow the input voltage from CR57. During the time that CR57 clamps, base capacitor C38 is held at about -15V by CR57,54, and 53. C36 is held at about -17V by CR57,54,51,50,49, and 52. The two volt difference back biases the blocking oscillator transistor base to emitter junction. When the input voltage starts positive again, it rises rapidly; CR52 and 53 are cut off, and the base and emitter capacitors follow their input signals.

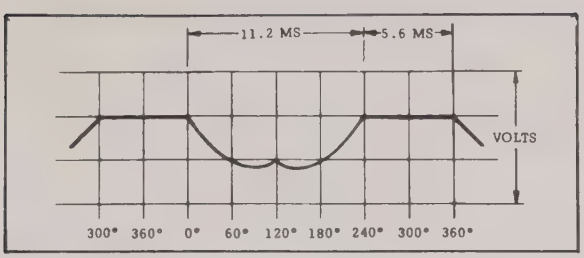


Figure 4-3. Three Phase Firing Circuit Waveform

4-45 METERING CIRCUITS

4-46 Both voltmeter and ammeter circuits consist of a 1.0mA type movement with the calibrating resistors contained on the rear printed board. The voltmeter is connected across the output terminals and is calibrated by means of rheostat R111. The ammeter circuit is connected across the internal current monitoring resistor and is calibrated by means of rheostat R112.

4-47 PROTECTION CIRCUITS

4-48 One of the protection features incorporated in the SCR-3 Series is the internal connection of 100Ω resistors between the sensing terminals and the output terminals (R91 and R94). These resistors provide protection should the sensing lead become open (particularly when using remote sensing). These resistors insure that the output voltage will rise only slightly if a sensing lead should become open.

4-49 Another protection circuit incorporated into the SCR-3 Series insures that no damage will occur internally should one or more of the input phases fail. This circuit monitors the input voltage and upon such a failure clamps the control signal off and then opens power relay K1. When the phase returns to normal, the operation reverses itself.

4-50 Diodes D36, D47, and D58 connected to the reset waveform of the three firing circuits and biased by resistor R105 connected back to the -32Vdc provide at their juncture (T. P. 49), a signal composed by the full wave rectification of the input phases. With the presence of three phases on the input, the average voltage at T. P. 49 is positive enough to bias Q21 and Q20 ON. In the event of failure of one or more phases, the average voltage becomes negative and reverse biases Q21 which turns off Q20. CR63 provides a 0.7 volt reverse bias which Q21 overcomes to turn Q20 on. Q20 saturates, when on, holding its collector at +5.5 volts. The relay coil in series with R108 is then across the auxiliary supply voltage, holding the relay on. R102 and CR62 across the coil reduce the spike at turn-off.

4-51 The collector of Q20 is also connected to R14, and CR4 going to the constant current input amplifier, and to R37, going to the OR gate amplifier, to turn these off and on with the relay.

SECTION V
MAINTENANCE

5-1 PERFORMANCE CHECK

5-2 EQUIPMENT REQUIRED

1. Line cord (4 wire) and plug for connection to 208/230/460Vac 3 phase, 60Hz source.
2. Oscilloscope.
3. Shorting strap for output terminals as follows:

Model	6450A	6453A	6456B	6459A
Rating	300A	200A	100A	350A

4. Ohmmeter.

5-3 PROCEDURE

1. Measure the resistance to chassis ground from each output bus and from each phase pin on the ac power connector at the rear of the unit (pin with the locating lug is connected to chassis ground internally) with the front panel circuit breaker in the ON position. Measured resistance should be in excess of one megohm on all measurements.

2. Check the ammeter and voltmeter on the front panel for zero set. If alignment is required, refer to Paragraph 5-9.

3. Rotate the front panel VOLTAGE control full counterclockwise (OFF) and CURRENT control full clockwise (ON). Check the programming terminal strip on the rear of the unit for normal strapping (see Figure 3-1). Place the front panel circuit breaker in the OFF position. Connect an oscilloscope to the output terminals using a 3 to 2 connector to connect the oscilloscope to the power source. Connect chassis ground to the negative output terminal. Set the vertical amplifier to ac coupling, 50mV/cm; horizontal to 2mS/cm sweep.

4. Connect the line cord to the power supply, then to the power source.

5. The first test is at no load. Place the circuit breaker in the ON position. Front panel meters should both read zero.

6. Rotate the VOLTAGE control full clockwise. Output voltage as read on the front panel voltmeter (ammeter should still read zero) should be as follows:

Model	6450A	6453A	6456B	6459A
Vdc	10±0.5	18±1	36±2	72±3

Turn down voltage to maximum rated output. Output ripple should be approximately 25mV peak to peak and 180Hz (one peak each 5.5mS). At no load the voltage decay on turn-down will be quite slow due to the large value capacitor bank (and the shunt bleeder) within the supply.

7. Rotate the CURRENT control full counterclockwise. Insure that supply turns off.

8. Rotate the front panel VOLTAGE and CURRENT controls full counterclockwise, de-energize the unit, and place a shorting strap across the output.

9. Rotate the VOLTAGE control clockwise about one half turn. Rotate the CURRENT control ON controlling the current to maximum and back again, reading the front panel ammeter.

10. Place the circuit breaker in the OFF position, rotate the VOLTAGE control counterclockwise. Remove the power cord from the power source and disconnect the short circuit across the output terminals.

5-4 POWER SUPPLY ADJUSTMENTS

5-5 METER ZERO-SETTING

5-6 The meter pointers must reset on the zero calibration mark on the meter scales when the instrument is at normal operating temperature, resting in its normal operating position and the instrument is turned off. To zero-set the meters proceed as follows:

1. Rotate adjustment screw on the front of the meter clockwise until the pointer is to the left of zero and further clockwise rotation will move the pointer up-scale towards zero.

2. Turn the adjustment screw clockwise until the pointer is exactly over the zero mark on the scale. If the screw is turned too far, repeat steps 1 and 2.

3. Turn meter adjustment screw counterclockwise about 15 degrees to break contact between adjustment screw and pointer mounting yoke, but not far enough to move the pointer back down-scale. If screw is turned too far, as shown by the needle moving, repeat the procedure. The meter is now zero-set for best accuracy and mechanical stability.

5-7 208/230/460VAC OPERATION

5-8 To change the operation of the supply to another three phase 60Hz voltage, the primary of the power transformer must be rewired, and for 460Vac operation, the circuit breaker must be changed. Wiring for 460Vac operation should be done at the factory. Figure 5-1 shows the three phase Wye primary connections for the three voltages. Nothing else need be done to change operation.

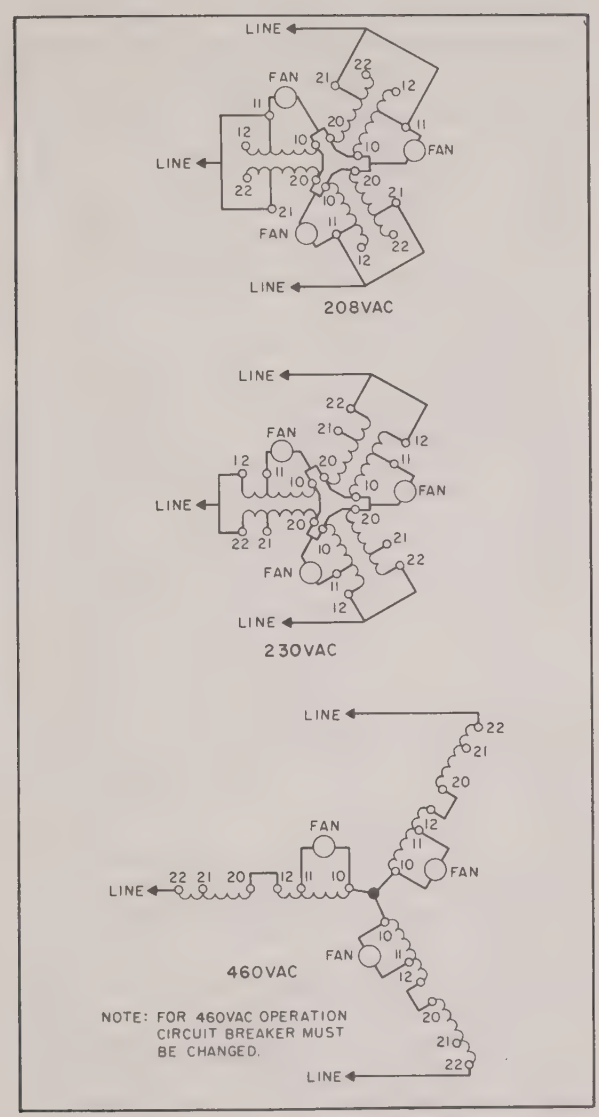


Figure 5-1. Input Power Wiring Diagram

5-9 MECHANICAL MAINTENANCE

5-10 COOLING SYSTEM MAINTENANCE

5-11 The SCR-3 Series utilizes forced air cooling on the rectifiers and transformer. The rectifiers are located in the heat sink compartment on the top of the unit running the full width of the chassis. As in any forced air cooling system, the compartment should be cleaned regularly (regularity will depend on the cleanliness of the air in the surrounding area). Remove the top cover of the supply and the heat sink compartment and clean with either a vacuum cleaner or with compressed air. Regular cleaning maintains the efficiency of the heat sinks and reduces the possibility of a short circuit to ground due to particle build-up around the rectifiers.

5-12 The blower motor bearing surfaces should be lubricated every six months as another preventative maintenance procedure.

5-13 PRINTED CIRCUIT BOARD ACCESS

5-14 The printed circuit board in the SCR-3 Series is located in the top rear of the chassis. Access to board may be accomplished by removal of the dust cover.

5-15 Removal of the dust cover provides access to the top (component side) of the board, but not to the bottom (copper side). The bottom of the board can be made accessible by removing the screws along the board and rotating out by its hinges.

CAUTION

Do not work on printed circuit boards before ac plug is removed and output capacitors are allowed to completely discharge.

5-16 Check that all wires are connected to the board (after work is completed) before replacing the board in its normal position.

5-17 PRINTED CIRCUIT BOARD SERVICING

5-18 Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50W maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick-drying acetate base cement having good electrical insulating properties.

5-19 A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

5-20 Use only high quality rosin core solder when repairing etched circuit boards. **NEVER USE PASTE FLUX.** After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

5-21 When replacing components with multiple mounting pins such as transistor sockets and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

5-22 The procedure for the replacement of a component is as follows:

1. Apply heat sparingly to lead of component to be replaced on the conductor side of board. Remove component.
2. Reheat solder in vacant eyelets and quickly insert a small awl to clean inside of hole or drill out hole with a #60 drill (#50 for medium

sized eyelet, #40 for large eyelet).

3. Bend clean trimmed leads on new part and carefully insert through eyelets in board.

4. Hold part against board and solder leads on conductor side of board.

5-23 POWER MESH RECTIFIER REPLACEMENT

5-24 In the event of a failure of one of the rectifiers (mounted on heat sinks in upper compartment) the following procedure should be followed for replacement:

1. Turn the unit off and remove the power cord from the power source.

2. Unscrew rectifier leads being careful to note where they were connected.

3. The rectifiers are threaded directly into the heat sink. Apply Penetrox A to the mating surface of the new rectifier but not to the threads.

4. Start the new rectifier in the threaded hole and tighten for the following maximum stud torque ratings:

Part No.	1N1184A		2N685A	1N1194A
Torque (in lbs.)	30		30	30
Part No.	C45	C80	2N2024	1N3260
Torque (in lbs.)	150	200	150	200

5-25 TROUBLESHOOTING

5-26 GENERAL

5-27 Pre-Turn On Checks. Before energizing the unit, check the following items:

1. Presence of 230Vac (or 208/460) at the plug which connects to the receptacle on the rear of the unit. (Check three phases.)

2. Straps on the programming terminal strip on the rear of the unit are placed properly and tightened.

3. Visually inspect for broken leads on the printed circuit board, controls on the front panel, and the meters. Inspect the main bridge for loose connections. Inspect the printed circuit board for burned, charred, or broken components.

NOTE

If component is found to be burned, charred, or broken on the printed circuit board, the cause of such a failure must then be located.

5-28 Open Loop. In certain types of power supply failure (such as uncontrolled output conditions) it is desirable to open the feedback loop in order to be able to troubleshoot the unit without exceeding voltage limits on the output capacitors, etc. In the SCR-3 Series, removal of transistors Q16-18 (blocking oscillator transistors) breaks the loop between the error amplifiers and the SCR's by disabling the blocking oscillators.

1. If an output still exists after this test, the trouble probably lies in the main power bridge rectifier.

2. If no output exists, the trouble lies in or prior to the blocking oscillator circuit and troubleshooting can proceed safely.

5-29 In-Circuit Ohmmeter Measurements of Main Power Bridge Rectifiers. If a failure is suspected in the power rectifier bridge circuit, a resistance measurement will most often identify the faulty component. Breakdown of the reverse characteristic (or forward characteristic in the case of SCR's) may be determined by measuring the resistance from the anode on rectifier, cathode on SCR, to their respective heat sink with the common side of the ohmmeter connected to the stud (heat sink).

5-30 Due to the characteristics of a bridge circuit, a resistance measurement test to find a faulty diode will not indicate which diode to be at fault. After finding a fault, it will be necessary to disconnect all the wires to the devices and make further measurements on the now disconnected diodes to determine which one is faulty.

5-31 When completely disconnected, SCR's should measure high resistance from cathode to anode and from gate to anode with either end connected to the common side of the ohmmeter. The resistance from gate to cathode should be approximately 200 ohms with either gate or cathode connected to the common side of the ohmmeter. The Power rectifiers should read high resistance with the cathode connected to the common side, and lower resistance when the anode is connected to the common side. It is important to note that the stud is the cathode of the fixed rectifiers but is the anode of the SCR's.

5-32 DC VOLTAGES

5-33 All measurements as made with a Simpson Model No. 269 VOM at medium input line voltage and zero output conditions except as indicated to be otherwise. Polarities indicated are for first test point ("FROM") with respect to second test point. All voltages are ±10% unless noted otherwise.

Table 5-1. Reference, Bias, and Filtered DC Voltages

Step	Meter Common	Meter Positive	Normal Vdc	Output Conditions
1	20	-out (or -S)	-30Vdc	360Hz Ripple
2	17	-out	-14 ± 2Vdc	
3	18	-out	-6.2 ± 0.4Vdc	
4	A10	-out	+6.2 ± 0.4Vdc	
5	19	-out	+6.4 ± 0.4Vdc	
6	47	-out	-28Vdc	Relay Off (Low Line)
7	47	-out	+5.5Vdc	Relay On
8	12	-out	+3 ± 0.5Vdc	Voltage as indicated for constant voltage mode and supply producing output power. When voltage control off, T. P. 12 about +0.5Vdc. When in constant current operation T. P. 12 about +6Vdc.
9	13	-out	+3 ± 0.5Vdc	Voltage as indicated for constant current mode and supply producing output power. When current control off, T. P. 13 about +0.5Vdc.
10	15	-out	Control Signal	In constant voltage mode: Voltage control off, T. P. 15, -13Vdc; Voltage just on, T. P. 15, -10Vdc; maximum load, T. P. 15, +2Vdc.

5-34 INSULATION AND CONTINUITY TESTS

5-35 Good insulation should exist between chassis ground and the output busses. In cases where the output busses display a low resistance to chassis ground, insure that the condition is not caused by extreme dirt buildup in the cooling compartment (bridge rectifiers).

5-36 Continuity measurements as outlined below will indicate the condition of the connecting wires between the printed circuit board, the SCR's and the output busses. Lack of continuity (in all instances, continuity means zero ohms resistance) can usually be traced to an open lead, most often where that lead is connected to an eyelet on a printed circuit board. **Continuity should exist between:**

1. The positive output bus and the + terminal on the printed circuit board.
2. The negative output bus and the — terminal on the printed circuit board.
3. Test points 25, 30, 35, and the gate leads of the SCR's (that is, continuity between 25 on the board and one SCR gate lead). Test points 26, 31, 36, and the cathode leads of the SCR's.

5-37 SYMPTOMS AND CLUES

5-38 Poor Load Regulation.

1. Reference voltage -6.2Vdc may be varying.
2. Insure that the current limit circuit is not starting to limit.
3. Insure the measurements of load regulation are done between +S and -S.
4. Check transistors Q1, 2, 8, 10, and 11.

5-39 Poor Line Regulation.

1. Check for presence and stability of -6.2V dc, -14Vdc and +6.4Vdc.
2. Insure that the current limit circuit is not starting to limit.
3. Check transistors Q1, 2, 8, 10, and 11.

5-40 Excessive Ripple Voltage.

1. If one or more SCR's fail to fire, adjust R87 and R88 for presence of three phases and balance ripple.

2. Check the filter capacitors for a leaky or shorted unit. Failure will probably be indicated by a blown or protruding membrane on the exhaust valve near the terminals.

5-41 No Output or Uncontrolled Output.

1. Check meters.

2. Check presence of input power (all phases).

3. Check presence of -32Vdc, -14Vdc, -6.2Vdc, +6.4Vdc.

4. Check the strapping on the rear programming terminal strip, particularly the voltage programming terminals.

5. Check that relay K1 "clicks" ON as line voltage is brought up.

6. Check test points 12, 13, and 15 for voltage as described in Paragraph 5-33, steps 8-10.

7. Check the bridge diodes (static and SCR's) with an ohmmeter for a faulty device.

8. Check for presence of gate pulses at SCR's.

5-42 Insufficient Output (Voltage and/or Current).

1. Check meters.

2. If insufficient voltage, insure the current limit is not operating.

3. Refer to Paragraph 5-41.

5-43 Current Limit Inoperative.

1. Check the straps on the programming terminal strip.

2. Check as per Paragraph 5-33, Step 9.

3. Check transistor Q9.

5-44 Excessive Drift.

1. Check the stability of -6.2Vdc.

2. Check the VOLTAGE control for excessive noise (R9).

3. Check for cold solder joints and/or noisy resistors (R1, R8, R2).

4. Check transistor Q1, Q2.

5-45 DETAILED CALIBRATION PROCEDURE

5-46 GENERAL

5-47 The following calibration procedure should be performed only after definite indications exist of trouble in the unit or after components have been changed in the circuitry where the adjustments are located. Indiscriminate adjustment of the internal controls to "refine" the settings may actually cause trouble.

5-48 The calibration procedures may be performed independently.

5-49 The differential or digital voltmeter serves two functions: that of a voltage standard (0.1%), and as a measuring device for measuring changes in voltage of millivolts. In the case where neither a digital nor differential voltmeter is available, substitute means can be derived to perform the same functions. Incremental voltages may be measured by connecting a dc source (another power supply or a battery, whose output voltage is approximately equal to the supply output voltage) in opposition to the output of the supply under test and measuring the difference between the two voltages. By adjusting the bucking voltage equal to the supply voltage (within 0.5Vdc) the most sensitive scale of a multimeter can be used to detect changes as small as 20mV in the supply voltage (assuming the bucking voltage stability is significantly better than 20mV for the measuring period).

5-50 REQUIRED TEST EQUIPMENT

5-51 A list of the required test equipment is shown in Table 5-2, together with recommended manufacturers and model numbers. A test equipment wiring diagram is shown in Figure 5-2.

Table 5-2. Recommended Test Equipment

Item	Instrument	Recommended Type	Characteristic and/or Use
1	Variable Transformer	General Radio Variac No. W30HG2	6.5KVA - open delta - 0-270Vac
2	Ammeter Shunt	Weston 0041227	6450--50mV, 500 amp shunt 6453--50mV, 200 amp shunt 6456--50mV, 100 amp shunt 6459--50mV, 50amp shunt All shunts are connected in series between load and supply.

Table 5-2. Recommended Test Equipment (Continued)

Item	Instrument	Recommended Type	Characteristic and/or Use
3	Voltmeter	Simpson No. 8800	0-250Vac voltmeter
4	Differential or Digital Voltmeter	John Fluke Co., Inc. No. 801H Differential voltmeter	Connected between +S and -S
5	Oscilloscope	℗ No. 130B/C	Connected to power supply line through 3:2 connector, vertical amplifier grounded to chassis ground.
6	Shorting Strap		Fabricated from copper bus strap or wire-connected as directed across output in series with meter shunt.

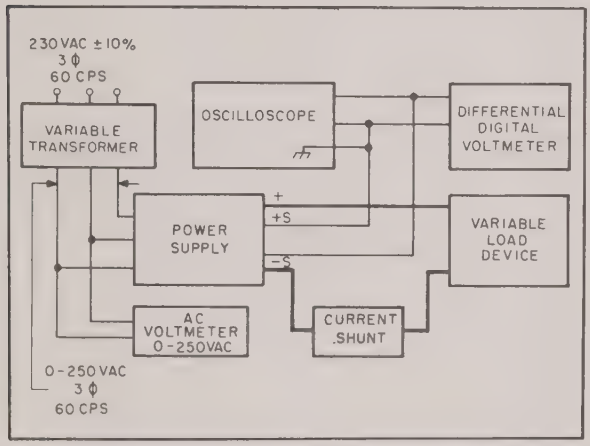


Figure 5-2. Test Equipment Connections

5-52 PROCEDURES

5-53 CALIBRATION OF VOLTAGE PROGRAMMING AND VOLTMETER

1. Connect differential/digital voltmeter to +S and -S terminals, rotate CURRENT control counterclockwise. Remove strap A2 to A3 on rear barrier strip to remove front panel pot from circuit. Connect a 0.1% resistor between +S and A2 taking the place of the pot. Value as follows:

Model	6450A	6453A	6456B	6459A
Value	1.6KΩ	3KΩ	6.2KΩ	12KΩ

2. Energize power supply.

3. Rotate CURRENT control clockwise until supply is in constant voltage operation.

4. Set output voltage to the following amount (as read on differential/digital voltmeter) by adjusting shunt R8 (across the pullout resistor R1):

Model	6450A	6453A	6456B	6459A
Vdc	8V±40mV	15V±75mV	31V±150mV	60V±300mV

5. Calibrate front panel voltmeter to voltage measured on differential/digital voltmeter with R111.

6. Rotate CURRENT control counterclockwise turn power supply off, and disconnect differential/digital voltmeter. Remove resistor and replace strap A2 to A3.

5-54 Firing Circuit Balance Adjustment (Balanced output ripple voltage).

1. Connect oscilloscope to +S and -S terminals, connect load device to output terminals, rotate VOLTAGE control counterclockwise and CURRENT control clockwise.

2. Energize power supply.

3. Set output conditions to approximately the following as read on front panel meters:

Model	6450A	6453A	6456B	6459A
Output	6.5V,300A	12.5V,200A	28V,10A	56V,50A

4. Set oscilloscope to 100mV/cm and 5mS/cm with ac coupling to vertical amplifier.

5. Adjust R87 and R88 for minimum 60Hz modulation of output ripple.

6. Rotate VOLTAGE control counterclockwise turn power supply off, and disconnect test equipment.

5-55 Calibration of Current Programming and Ammeter. The factory sets the current programming as a protection feature for a current limit of 10% over the maximum rated output at full pot setting. If more accurate programming is required, proceed as follows:

1. Connect load devices, rotate VOLTAGE control ccw. Remove strap from A5 to A6 on rear barrier strip (taking current front panel pot out of circuit). Connect a 200Ω ±0.1% resistor between A4 and A6.

2. Energize power supply.

3. Rotate VOLTAGE control cw until supply is in constant current operation.

4. Set output current to the following by adjusting shunt R22 (across the pullout resistor R12):

Model	6450A	6453A	6456B	6459A
Amps	300±1.5	200±1	100±0.5	50±0.25

5. Calibrate front panel ammeter to current output by adjusting R112.

6. Rotate voltage control ccw, turn supply OFF. Remove 200 ohm resistor from A4 to A6 and replace strap A5 to A6.

5-56 Transient Response Adjustment.

1. Connect load devices, connect oscilloscope to +S and -S terminals, rotate VOLTAGE control counterclockwise and CURRENT control clockwise.

2. Set oscilloscope to 500mV/cm ac and 50mS/cm sweep speed.

3. Energize power supply.

4. Set output voltage to maximum rated output and set load to switch from maximum load current to half load current.

5. Switch load and observe that output voltage returns to within the following mV of nominal within 50mS. If return is too slow or there is excessive ringing, adjust R10.

Model	6450A	6453A	6456B	6459A
Millivolts	150	150	300	600

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-4 lists parts in alphanumeric order by reference designators and provides the following information:

a. Reference Designators. Refer to Table 6-1.

b. Description. Refer to Table 6-2 for abbreviations.

c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.

d. Manufacturer's Part Number or Type.

e. Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.

f. Hewlett-Packard Part Number.

g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 6-4, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

A	= assembly	E	= miscellaneous electronic part
B	= blower (fan)	F	= fuse
C	= capacitor	J	= jack, jumper
CB	= circuit breaker	K	= relay
CR	= diode	L	= inductor
DS	= device, signaling (lamp)	M	= meter

Table 6-1. Reference Designators (Continued)

P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
Q	= transistor		
R	= resistor	VR	= zener diode
S	= switch	X	= socket
T	= transformer	Z	= integrated circuit or network
TB	= terminal block		
TS	= thermal switch		

Table 6-2. Description Abbreviations

A	= ampere	mfr	= manufacturer
ac	= alternating current	mod.	= modular or modified
assy.	= assembly	mtg	= mounting
bd	= board	n	= nano = 10^{-9}
bkt	= bracket	NC	= normally closed
°C	= degree Centigrade	NO	= normally open
		NP	= nickel-plated
cd	= card	Ω	= ohm
coef	= coefficient	obd	= order by description
comp	= composition		
CRT	= cathode-ray tube	OD	= outside diameter
CT	= center-tapped	p	= pico = 10^{-12}
dc	= direct current	P.C.	= printed circuit
DPDT	= double pole, double throw	pot.	= potentiometer
		p-p	= peak-to-peak
DPST	= double pole, single throw	ppm	= parts per million
elect	= electrolytic	pvr	= peak reverse voltage
encap	= encapsulated	rect	= rectifier
F	= farad	rms	= root mean square
°F	= degree Farenheit	Si	= silicon
fxd	= fixed	SPDT	= single pole, double throw
Ge	= germanium		
H	= Henry	SPST	= single pole, single throw
Hz	= Hertz		
IC	= integrated circuit	SS	= small signal
		T	= slow-blow
ID	= inside diameter	tan.	= tantulum
incnd	= incandescent	Ti	= titanium
k	= kilo = 10^{3}	V	= volt
m	= milli = 10^{-3}	var	= variable
M	= mega = 10^{6}	ww	= wirewound
μ	= micro = 10^{-6}	W	= Watt
met.	= metal		

Table 6-3. Code List of Manufacturers

CODE NO.	MANUFACTURER	ADDRESS
00629	EBY Sales Co., Inc.	Jamaica, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00853	Sangamo Electric Co. S. Carolina Div.	Pickens, S.C.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Semiconductor-Components Div.	Dallas, Texas
01686	RCL Electronics, Inc.	Manchester, N.H.
01930	Amerock Corp.	Rockford, Ill.
02107	Sparta Mfg. Co.	Dover, Ohio
02114	Ferroxcube Corp.	Saugerties, N.Y.
02606	Fenwal Laboratories	Morton Grove, Ill.
02660	Amphenol Corp.	Broadview, Ill.
02735	Radio Corp. of America, Solid State and Receiving Tube Div.	Somerville, N.J.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co. Inc.	Cedar Knolls, N.J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04072	ADC Electronics, Inc.	Harbor City, Calif.
04213	Caddell & Burns Mfg. Co. Inc.	Mineola, N.Y.
04404	*Hewlett-Packard Co. Palo Alto Div.	Palo Alto, Calif.
04713	Motorola Semiconductor Prod. Inc.	Phoenix, Arizona
05277	Westinghouse Electric Corp. Semiconductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	Grand Junction, Colo.
05820	Wakefield Engr. Inc.	Wakefield, Mass.
06001	General Elect. Co. Electronic Capacitor & Battery Dept.	Irmo, S.C.
06004	Bassik Div. Stewart-Warner Corp.	Bridgeport, Conn.
06486	IRC Div. of TRW Inc. Semiconductor Plant	Lynn, Mass.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co.	Penacook, N.H.
06666	General Devices Co. Inc.	Indianapolis, Ind.
06751	Semcor Div. Components, Inc.	Phoenix, Arizona
06776	Robinson Nugent, Inc.	New Albany, Ind.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07263	Fairchild Camera and Instrument Corp. Semiconductor Div.	Mountain View, Calif.
07387	Birtcher Corp., The	Los Angeles, Calif.
07397	Sylvania Electric Prod. Inc. Sylvania Electronic Systems Western Div.	Mountain View, Calif.
07716	IRC Div. of TRW Inc. Burlington Plant	Burlington, Iowa
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Co. Components Div. Semiconductor Operation	Mountain View, Calif.
08484	Breeze Corporations, Inc.	Union, N.J.
08530	Reliance Mica Corp.	Brooklyn, N.Y.
08717	Sloan Company, The	Sun Valley, Calif.
08730	Vemaline Products Co. Inc.	Wyckoff, N.J.
08806	General Elect. Co. Miniature Lamp Dept.	Cleveland, Ohio
08863	Nylomatic Corp.	Norrisville, Pa.
08919	RCH Supply Co.	Vernon, Calif.
09021	Airco Speer Electronic Components	Bradford, Pa.
09182	*Hewlett-Packard Co. New Jersey Div.	Berkeley Heights, N.J.
09213	General Elect. Co. Semiconductor Prod. Dept.	Buffalo, N.Y.
09214	General Elect. Co. Semiconductor Prod. Dept.	Auburn, N.Y.
09353	C & K Components Inc.	Newton, Mass.
09922	Burndy Corp.	Norwalk, Conn.
11115	Wagner Electric Corp. Tung-Sol Div.	Bloomfield, N.J.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of Cal. Inc.	So. Pasadena, Calif.
11502	IRC Div. of TRW Inc. Boone Plant	Boone, N.C.
11711	General Instrument Corp Rectifier Div.	Newark, N.J.
12136	Philadelphia Handle Co. Inc.	Camden, N.J.
12615	U.S. Terminals, Inc.	Cincinnati, Ohio
12617	Hamlin Inc.	Lake Mills, Wisconsin
12697	Clarostat Mfg. Co. Inc.	Dover, N.H.
13103	Thermalloy Co.	Dallas, Texas
14493	*Hewlett-Packard Co. Loveland Div.	Loveland, Colo.
14655	Cornell-Dubilier Electronics Div. Federal Pacific Electric Co.	Newark, N.J.
14936	General Instrument Corp. Semiconductor Prod. Group	Hicksville, N.Y.
15801	Fenwal Elect.	Framingham, Mass.
16299	Corning Glass Works, Electronic Components Div.	Raleigh, N.C.

*Use Code 28480 assigned to Hewlett-Packard Co., Palo Alto, California

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
16758	Delco Radio Div. of General Motors Corp.	Kokomo, Ind.
17545	Atlantic Semiconductors, Inc.	Asbury Park, N.J.
17803	Fairchild Camera and Instrument Corp Semiconductor Div. Transducer Plant	Mountain View, Calif.
17870	Daven Div. Thomas A. Edison Industries McGraw-Edison Co.	Orange, N.J.
18324	Signetics Corp.	Sunnyvale, Calif.
19315	Bendix Corp. The Navigation and Control Div.	Teterboro, N.J.
19701	Electra/Midland Corp.	Mineral Wells, Texas
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp. Electronics Div.	Mountain View, Calif.
22753	UID Electronics Corp.	Hollywood, Fla.
23936	Pamotor, Inc.	Pampa, Texas
24446	General Electric Co.	Schenectady, N.Y.
24455	General Electric Co. Lamp Div. of Consumer Prod. Group	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	LTV Electrosystems Inc Memcor/Components Operations	Huntington, Ind.
26982	Dynacool Mfg. Co. Inc.	Saugerties, N.Y.
27014	National Semiconductor Corp.	Santa Clara, Calif.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
28875	IMC Magnetics Corp. New Hampshire Div.	Rochester, N.H.
31514	SAE Advance Packaging, Inc.	Santa Ana, Calif.
31827	Budwig Mfg. Co.	Ramona, Calif.
33173	G.E. Co. Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
43334	New Departure-Hyatt Bearings Div. General Motors Corp.	Sandusky, Ohio
44655	Ohmite Manufacturing Co.	Skokie, Ill.
46384	Penn Engr. and Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
49956	Raytheon Co.	Lexington, Mass.
55026	Simpson Electric Co. Div. of American Gage and Machine Co.	Chicago, Ill.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
58849	Syntron Div. of FMC Corp.	Homer City, Pa.
59730	Thomas and Betts Co.	Philadelphia, Pa.
61637	Union Carbide Corp.	New York, N.Y.
63743	Ward Leonard Electric Co.	Mt. Vernon, N.Y.
70563	Amperite Co. Inc.	Union City, N.J.
70901	Beemer Engrg. Co.	Fort Washington, Pa.
70903	Belden Corp.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionic Corp.	Cambridge, Mass.
71400	Bussmann Mfg. Div. of McGraw & Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	I.T.T. Cannon Electric Inc.	Los Angeles, Calif.
71590	Globe-Union Inc. Centralab Div.	Milwaukee, Wis.
71700	General Cable Corp. Cornish Wire Co. Div.	Williamstown, Mass.
71707	Coto Coil Co. Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co. Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72699	General Instrument Corp.	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72962	Elastic Stop Nut Div. of Amerace Esna Corp.	Union, N.J.
72982	Erie Technological Products Inc.	Erie, Pa.
73096	Hart Mfg. Co.	Hartford, Conn.
73138	Beckman Instruments Inc. Helipot Div.	Fullerton, Calif.
73168	Fenwal, Inc.	Ashland, Mass.
73293	Hughes Aircraft Co. Electron Dynamics Div.	Torrance, Calif.
73445	Amperex Electronic Corp.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Products, Inc.	Chicago, Ill.
74193	Heinemann Electric Co.	Trenton, N.J.
74545	Hubbell Harvey Inc.	Bridgeport, Conn.
74868	Amphenol Corp. Amphenol RF Div.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	IRC Div. of TRW, Inc.	Philadelphia, Pa.
75183	*Howard B. Jones Div. of Cinch Mfg. Corp.	New York, N.Y.
75376	Kurz and Kasch, Inc.	Dayton, Ohio
75382	Kilka Electric Corp.	Mt. Vernon, N.Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76381	Minnesota Mining and Mfg. Co.	St. Paul, Minn.
76385	Minor Rubber Co. Inc.	Bloomfield, N.J.
76487	James Millen Mfg. Co. Inc.	Malden, Mass.
76493	J.W. Miller Co.	Compton, Calif.

*Use Code 71785 assigned to Cinch Mfg. Co., Chicago, Ill.

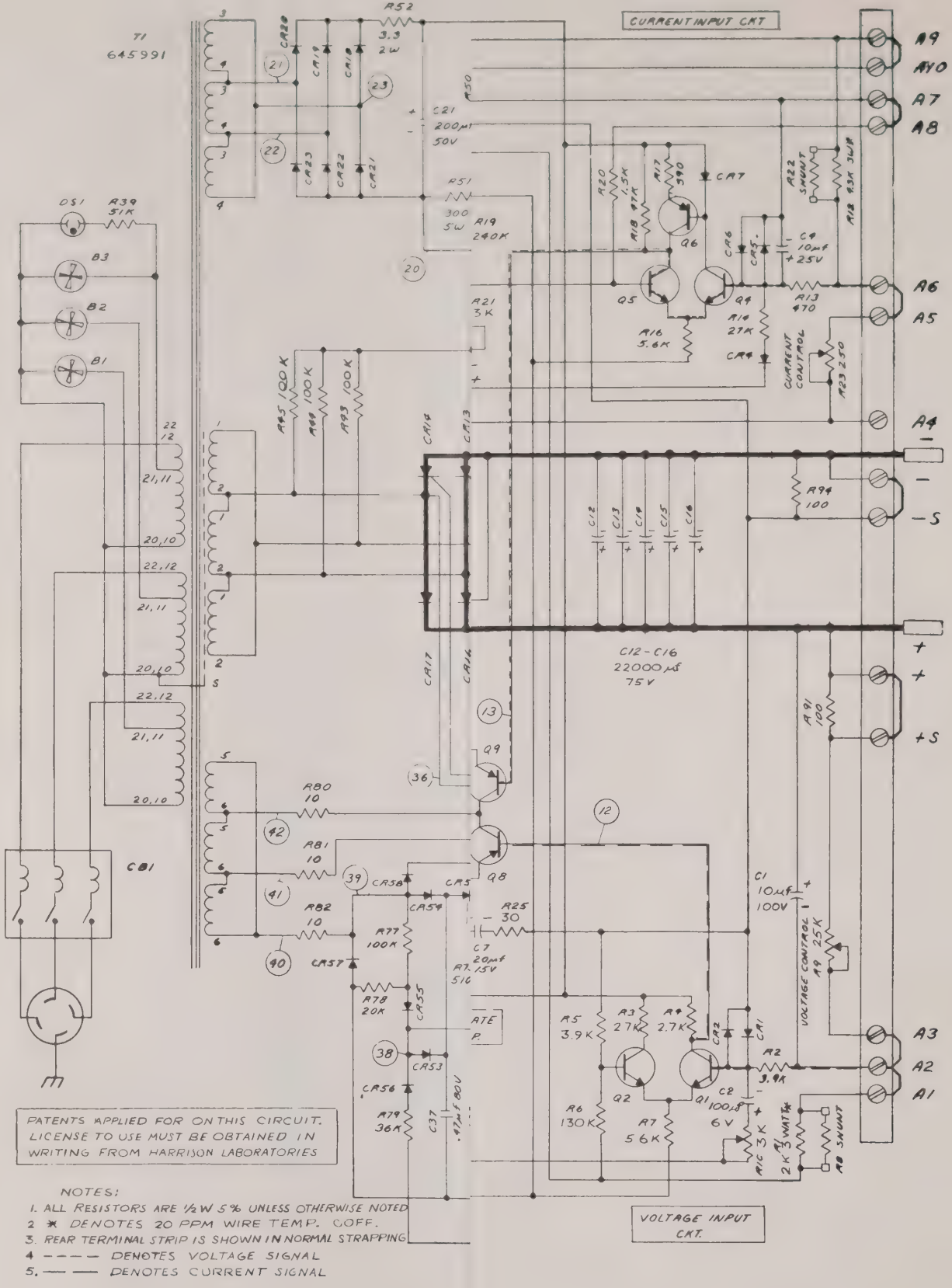
Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
76530	Cinch	City of Industry, Calif.
76854	Oak Mfg. Co. Div. of Oak Electro/Netics Corp.	Crystal Lake, Ill.
77068	Bendix Corp., Electrodynamics Div.	No. Hollywood, Calif.
77122	Palnut Co.	Mountainside, N.J.
77147	Patton-MacGuyer Co.	Providence, R.I.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine and Foundry Co. Potter and Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Illinois Tool Works Inc. Shakeproof Div.	Elgin, Ill.
78452	Everlock Chicago, Inc.	Chicago, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Div. San Fernando Electric Mfg. Co. Inc.	Newburgh, N.Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78584	Stewart Stamping Corp.	Yonkers, N.Y.
79136	Waldes Kohinoor, Inc.	L.I.C., N.Y.
79307	Whitehead Metals Inc.	New York, N.Y.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Co.	Mt. Kisco, N.Y.
80031	Mepco Div. of Sessions Clock Co.	Morristown, N.J.
80294	Bourns, Inc.	Riverside, Calif.
81042	Howard Industries Div. of Msl Ind. Inc.	Racine, Wisc.
81073	Grayhill, Inc.	La Grange, Ill.
81483	International Rectifier Corp.	El Segundo, Calif.
81751	Columbus Electronics Corp.	Yonkers, N.Y.
82099	Goodyear Sundries & Mechanical Co. Inc.	New York, N.Y.
82142	Airco Speer Electronic Components	Du Bois, Pa.
82219	Sylvania Electric Products Inc. Electronic Tube Div. Receiving Tube Operations	Emporium, Pa.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls Inc. Control Products Group	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp. Electric Power Div.	Eatontown, N.J.
83330	Herman H. Smith, Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Div. of Amerace Esna Corp.	Brookfield, Mass.
83508	Grant Pulley and Hardware Co.	West Nyack, N.Y.
83594	Burroughs Corp. Electronic Components Div.	Plainfield, N.J.
83835	U.S. Radium Corp.	Morristown, N.J.
83877	Yardeny Laboratories, Inc.	New York, N.Y.
84171	Arco Electronics, Inc.	Great Neck, N.Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
86684	RCA Corp. Electronic Components	Harrison, N.J.
86838	Rummel Fibre Co.	Newark, N.J.
87034	Marco & Oak Industries a Div. of Oak Electro/netics Corp.	Anaheim, Calif.
87216	Philco Corp. Lansdale Div.	Lansdale, Pa.
87585	Stockwell Rubber Co. Inc.	Philadelphia, Pa.
87929	Tower-Olschan Corp.	Bridgeport, Conn.
88140	Cutler-Hammer Inc. Power Distribution and Control Div. Lincoln Plant	Lincoln, Ill.
88245	Litton Precision Products Inc, USECO Div. Litton Industries	Van Nuys, Calif.
90634	Gulton Industries Inc.	Metuchen, N.J.
90763	United-Car Inc.	Chicago, Ill.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell Inc. Div. Micro Switch	Freeport, Ill.
92825	Whitso, Inc.	Schiller Pk., Ill.
93332	Sylvania Electric Prod. Inc. Semi-conductor Prod. Div.	Woburn, Mass.
93410	Essex Wire Corp. Stemco Controls Div.	Mansfield, Ohio
94144	Raytheon Co. Components Div. Ind. Components Oper.	Quincy, Mass.
94154	Wagner Electric Corp. Tung-Sol Div.	Livingston, N.J.
94222	Southco Inc.	Lester, Pa.
95263	Leecraft Mfg. Co. Inc.	L.I.C., N.Y.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95712	Bendix Corp. Microwave Devices Div.	Franklin, Ind.
95987	Weckesser Co. Inc.	Chicago, Ill.
96791	Amphenol Corp. Amphenol Controls Div.	Janesville, Wis.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97702	IMC Magnetics Corp. Eastern Div.	Westbury, N.Y.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98410	ETC Inc.	Cleveland, Ohio
98978	International Electronic Research Corp.	Burbank, Calif.
99934	Renbrandt, Inc.	Boston, Mass.

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	℗ Stock No.	RS
C1	fxd, elect 10μf 100vdc	1	30D106G100DD4	Sprague	56289	0180-0091	1
C2	fxd, elect 100μf 6vdc	1	30D107G006DB4	Sprague	56289	0180-1734	1
C3,6,10, 11,17,19, 22,23, 39-42	NOT ASSIGNED	-	-	-	-	-	-
C4	fxd, elect 10μf 25vdc	1	30D106G025BB4	Sprague	56289	0180-0059	1
C5,7,44	fxd, elect 20μf 15vdc	3	30D206G015BB4	Sprague	56289	0180-0300	1
C8,24,29, 34,43	fxd, elect 5μf 65vdc	5	D33689	Sprague	56289	0180-1836	1
C9	fxd, elect 200μf 15vdc	1	30D207G015DF4	Sprague	56289	0180-0104	1
C12-16	fxd, elect 22,000μf 75vdc	5	D38829	℗	09182	0180-1929	1
C18	fxd, paper 1μf 200vdc	1	118P1059293	Sprague	56289	0160-2465	1
C20	fxd, elect 100μf 25vdc	1	30D107G025DH4	Sprague	56289	0180-0094	1
C21	fxd, elect 200μf 65vdc	1	D70996	Sprague	56289	0180-1884	1
C25,30,35	fxd, film .033μf 200vdc	3	192P33392	Sprague	56289	0160-0163	1
C26,31,36	fxd, elect 1μf 35vdc	3	150D105X9035A2	Sprague	56289	0180-0291	1
C27,32,37	fxd, film .47μf 80vdc	3	192P4749R8	Sprague	56289	0160-0970	1
C28,33,38	fxd, film .082μf 200vdc	3	192P82392	Sprague	56289	0160-0167	1
CB1(208Vac)	Circuit breaker 20 amp	1	AM333 Curve 4	Heineman	74193	2110-0211	1
CB1(460Vac)	Circuit breaker 10 amp	1	48-300-S-H	E.T.A.	06402	2110-0210	1
CR1,2,4-7, 26,30-37, 41-48, 52-58,61, 64,65	Diode, si. 200prv 250mw	33		℗	09182	1901-0033	11
CR3,8,24, 25,59,60	NOT ASSIGNED	-	-	-	-	-	-
CR9,27-29, 38-40, 49-51	Rect. si. 200ma 15prv	10		℗	09182	1901-0461	6
CR10	Rect. si. 40A 200prv	1	1N1186AR	Westinghouse	02577	1901-0319	1
CR11	NOT USED	-	-	-	-	-	-
CR12-14	SCR 35amp 200prv	3	C135BX4	G.E.	03508	1884-0042	3
CR15-17	Rect. si. 20amp 220prv	3	1N250C	G.E.	03508	1901-0310	3
CR18-23,62	Rect. si. 500ma 200prv	7	1N3253	R.C.A.	02735	1901-0389	6
CR63	Rect. si. 3amp 200prv	1	MR1032B	Motorola	04713	1901-0416	1
DS1	Indicator Light, neon	1	599-124	Drake	72765	1450-0048	1
K1	Relay - 200amp	1	6041H170A	Cutler-Hammer	15605	0490-0363	1
L1	Choke, 1.8μh	1		℗	09182	9100-1884	1
Q1,2,4, 5,21	SS NPN si.	5		℗	09182	1854-0027	5
Q3,7,12, 15,19	NOT ASSIGNED	-	-	-	-	-	-
Q6,8,9, 16-18	SS PNP Ger.	7	2N1377	T.I.	01295	1850-0170	6
Q10,11,14	SS NPN si.	3		℗	09182	1854-0244	3
Q13	SS PNP si.	1	40362	R.C.A.	02735	1853-0041	1
Q20	Power PNP Ger.	1		℗	09182	1850-0168	1
R1	fxd, ww 2KΩ ±5% 3w	1	242E2025	Sprague	56289	0811-1806	1
R2,5,54	fxd, comp 3.9KΩ ±5% ½w	3	EB-3925	A.B.	01121	0686-3925	1

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	hp Stock No.	RS
R3, 4	fxd, comp 2.7KΩ ±5% ½w	2	EB-2725	A.B.	01121	0686-2725	1
R6	fxd, comp 130KΩ ±5% ½w	1	EB-1345	A.B.	01121	0686-1345	1
R7, 16	fxd, comp 5.6KΩ ±5% ½w	2	EB-5625	A.B.	01121	0686-5625	1
R8, 22, 109	fxd, comp SELECTED ±5% ½w	3	Type EB	A.B.	01121		1
R9	var. ww 25KΩ	1		hp	09182	2100-1862	1
R10	var. ww 3KΩ (Modify)	1	Type 110-F4	C.T.S.	11236	2100-1823	1
R11, 15, 38, 46, 53, 83-86, 89, 90, 92, 110	NOT ASSIGNED	-	-	-	-	-	-
R12	fxd, ww 4.3KΩ ±5% 3w	1	242E4325	Sprague	56289	0811-1811	1
R13, 26, 29	fxd, comp 470Ω ±5% ½w	3	EB-4715	A.B.	01121	0686-4715	1
R14, 28	fxd, comp 27KΩ ±5% ½w	2	EB-2735	A.B.	01121	0686-2735	1
R17	fxd, comp 390Ω ±5% ½w	1	EB-3915	A.B.	01121	0686-3915	1
R18	fxd, comp 47KΩ ±5% ½w	1	EB-4735	A.B.	01121	0686-4735	1
R19	fxd, comp 240KΩ ±5% ½w	1	EB-2445	A.B.	01121	0686-2445	1
R20	fxd, comp 1.5KΩ ±5% ½w	1	EB-1525	A.B.	01121	0686-1525	1
R21, 31	fxd, comp 3KΩ ±5% ½w	2	EB-3025	A.B.	01121	0686-3025	1
R23	var. ww 250Ω	1		hp	09182	2100-1889	1
R24, 87, 88, 111	var. ww 5KΩ (Modify)	4	Type 110-F4	C.T.S.	11236	2100-1824	1
R25	fxd, comp 30Ω ±5% ½w	1	EB-3005	A.B.	01121	0686-3005	1
R27, 60	fxd, comp 9.1KΩ ±5% ½w	2	EB-9125	A.B.	01121	0686-9125	1
R30	fxd, comp 43Ω ±5% ½w	1	EB-4305	A.B.	01121	0686-4305	1
R32	fxd, comp 10KΩ ±5% ½w	1	EB-1035	A.B.	01121	0686-1035	1
R33	fxd, comp 1KΩ ±5% ½w	1	EB-1025	A.B.	01121	0686-1025	1
R34, 47, 91, 94	fxd, comp 100Ω ±5% ½w	4	EB-1015	A.B.	01121	0686-1015	1
R35, 37, 68, 76	fxd, comp 6.8KΩ ±5% ½w	4	EB-6825	A.B.	01121	0686-6825	1
R36, 62, 70, 78	fxd, comp 20KΩ ±5% ½w	4	EB-2035	A.B.	01121	0686-2035	1
R39	fxd, comp 51KΩ ±5% ½w	1	EB-5135	A.B.	01121	0686-5135	1
R40, 41	fxd, ww 40Ω ±5% 55w	2	55S/817 MTG	W.L.	63743	0811-1966	1
R42	fxd, comp 18Ω ±5% ½w	1	EB-1805	A.B.	01121	0686-1805	1
R43-45, 61, 69, 77, 103	fxd, comp 100KΩ ±5% ½w	7	EB-1045	A.B.	01121	0686-1045	1
R48	fxd, comp 910Ω ±5% ½w	1	EB-9115	A.B.	01121	0686-9115	1
R49, 95	fxd, comp 200Ω ±5% ½w	2	EB-2015	A.B.	01121	0686-2015	1
R50	fxd, ww 200Ω ±5% 5w	1	Type 5XM	W.L.	63743	0811-1204	1
R51	fxd, ww 300Ω ±5% 5w	1	Type 5XM	W.L.	63743	0811-1215	1
R52	fxd, ww 3.3Ω ±5% 2w	1	Type BWH	I.R.C.	07716	0811-1672	1
R55	fxd, comp 12KΩ ±5% ½w	1	EB-1235	A.B.	01121	0686-1235	1
R56, 64, 72, 80-82	fxd, comp 10Ω ±5% ½w	6	EB-1005	A.B.	01121	0686-1005	2
R57, 65, 73	fxd, met. ox 1.8KΩ ±5% 2w	3	Type C42S	Corning	16299	0698-3640	1
R58, 66, 74	fxd, comp 2.4KΩ ±5% ½w	3	EB-2425	A.B.	01121	0686-2425	1
R59, 67, 75	fxd, comp 510Ω ±5% ½w	3	EB-5115	A.B.	01121	0686-5115	1
R63, 71, 79	fxd, comp 36KΩ ±5% ½w	3	EB-3635	A.B.	01121	0686-3635	1
R93	fxd, film 61.9KΩ ±1% 1/8w	1	MF5C-D61.9	Electra	19701	0757-0460	1
R96	fxd, ribbon .0076Ω ±40ppm	1	(Sensing Resistor)	hp	09182	06459-80002	1
R97	fxd, comp 3.3KΩ ±5% ½w	1	EB-3325	A.B.	01121	0686-3325	1
R98	fxd, comp 22KΩ ±5% ½w	1	EB-2235	A.B.	01121	0686-2235	1
R99	fxd, comp 51Ω ±5% ½w	1	EB-5105	A.B.	01121	0686-5105	1
R100	fxd, comp 82Ω ±5% ½w	1	EB-8205	A.B.	01121	0686-8205	1
R101	fxd, comp 100Ω ±5% 1w	1	GB-1015	A.B.	01121	0689-1015	1

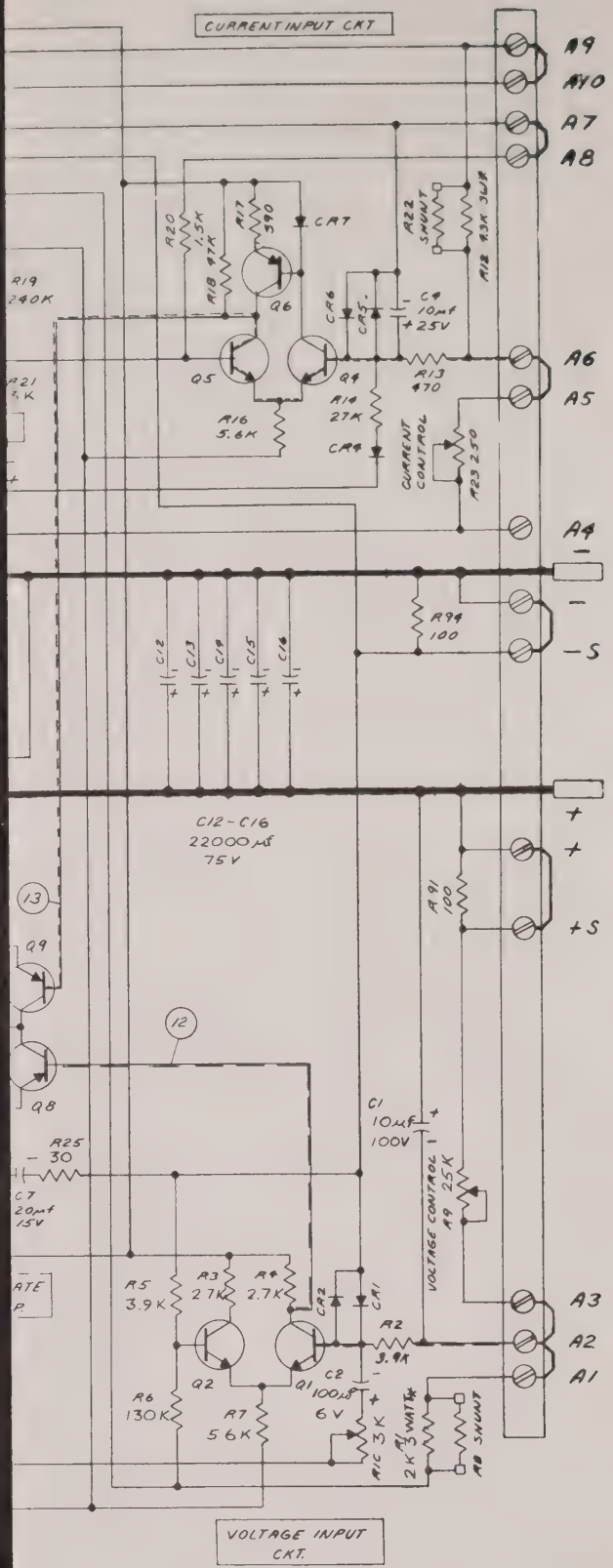
Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	Stock No.	RS
R102	fxd, comp 62Ω ±5% ½w	1	EB-6205	A.B.	01121	0686-6205	1
R104	fxd, comp 8.2KΩ ±5% ½w	1	EB-8225	A.B.	01121	0686-8225	1
R105	fxd, comp 3.9KΩ ±5% ½w	1	EB-3925	A.B.	01121	0686-3925	1
R106,107	fxd, ww 820Ω ±5% 3w	2	242E8215	Sprague	56289	0813-0010	1
R108	fxd, ww 40Ω ±5% 20w	1	2BRS53B	H.H.	73978	0811-1901	1
R112	var, ww 250Ω (Modify)	1	Type 110-F4	C.T.S.	11236	2100-0439	1
T1	Power transformer	1		hp	09182	9100-1883	1
T2-4	Pulse transformer	3		hp	09182	9100-1803	1
VR1,2	Diode, zener 6.2V	2	1N821	Motorola	04713	1902-0761	2
VR3	Diode, zener 20.5V ±5% 400mw	1		hp	09182	1902-0182	1
	Chassis welding assembly	1		hp	09182	5060-6134	
	Capacitor clamp welding assembly	1		hp	09182	5060-6135	
	Capacitor tray	1		hp	09182	5000-6154	
	Fan bracket	4		hp	09182	5000-6156	
	Front panel (208Vac)	1		hp	09182	06459-60001	
	Front panel (460Vac)	1		hp	09182	06459-60002	
	Bussbar	1		hp	09182	5020-5576	
	Bussbar	1		hp	09182	5020-5577	
	Bussbar	1		hp	09182	5000-6142	
	Bussbar	1		hp	09182	5000-6159	
	Top cover	1		hp	09182	5000-6160	
	Flyback heat sink	1		hp	09182	06459-20001	
	SCR heat sink	1		hp	09182	06459-20002	
	Diode heat sink	1		hp	09182	5020-5581	
	P.C.Bd. ass'y. (Includes components)	1		hp	09182	06459-60020	
	Printed circuit board (Blank)	1		hp	09182	5020-5582	
	Output chassis (208Vac)	(1)		hp	09182	5060-6136	
	Output chassis (230Vac)	1		hp	09182	5060-6137	
	Output chassis (460Vac)	(1)		hp	09182	5060-6138	
	Meter, 0-80V 4½"	1	100170	hp	09182		1
	Meter, 0-50A 4½"	1	100171	hp	09182	1120-1180	1
	Cable clamp	2	T4-4	Whitehead Metals	79307	1400-0330	1
	Heat sink	1	#3AL635-2R	Birtcher	07387	1205-0002	1
	Transistor socket	10	3305	Elco	91662	1200-0708	6
	Barrier strip	1	599-2-14	Kulka	73582	0360-1233	1
	Jumper	7	422-13-11-013	Cinch	71785	0360-1143	2
	Knob	2		hp	09182	0370-0029	1
	Shoulder washer	6		hp	09182	2190-0491	2
	Shoulder washer	8		hp	09182	2190-0492	2
	Standoff post	2		hp	09182	0380-0712	1
	Standoff post	2		hp	09182	0380-0713	1
	Rubber foot	8	F7264A	Bud	71218	0403-0087	2
	Oval handle 9"	2	NP16	Vemaline	08730	1440-0057	1
	Spacer 3/8 dia #10 x ¼ lg	4	9317-B-194-3A	Amatom	06540	0380-0704	1
	Standoff ¼ dia	8	6-32 x 3/8	hp	09182	0380-0175	2
	Connector	1	7413G	Hubbell	74545	1251-1570	1
	Fan motor	3	G5-CW-27255-6	Gen. Indus.	73793	3140-0010	1
	Fan blade	3	4" dia	hp	09182	3160-0034	1
	Fan motor housing casting	3		hp	09182	5243-20A	1
	Plug	1	#05-15541G	Hubbell	74545	1251-1635	1



NOTES:

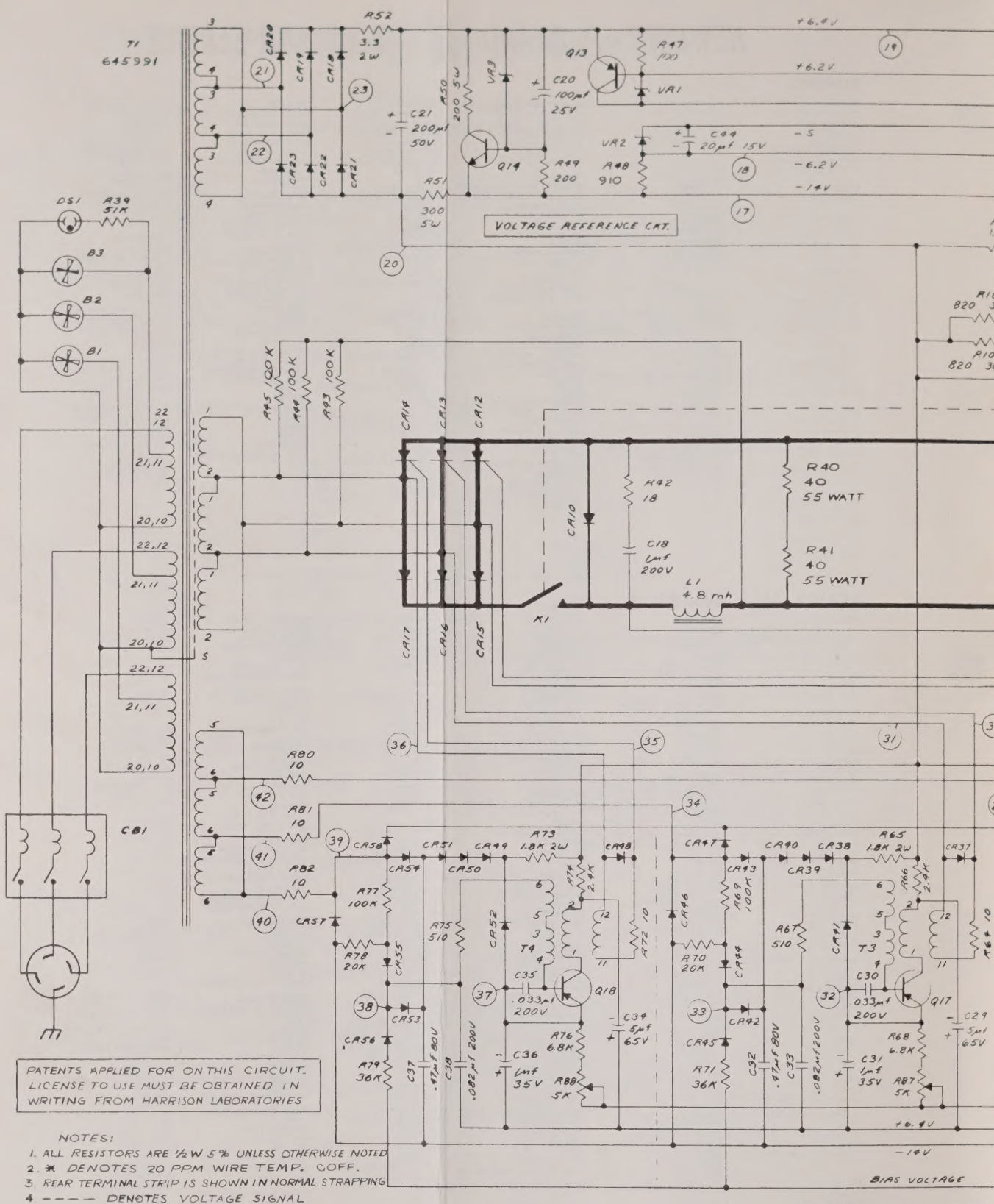
1. ALL RESISTORS ARE ½W 5% UNLESS OTHERWISE NOTED
2. * DENOTES 20 PPM WIRE TEMP. COEF.
3. REAR TERMINAL STRIP IS SHOWN IN NORMAL STRAPPING
4. – – – – DENOTES VOLTAGE SIGNAL
5. —— —— DENOTES CURRENT SIGNAL

Model 6459A, Schematic Diagram



Model 6459A, Schematic Diagram

CONTROL SIGNAL
PHASE PROTECTION CKT
ADJUST FOR 72 V CEILING
CURRENT SENSING RESISTOR
R54 3.9K
R55 12K
R56 10
R57 1.8K 2W
R58 2.9K
R59 510
R60 1K
R62 20K
R63 36K
R31 3K
R32 10K
R33 1K
R34 100
R35 6.8K
R36 20K
R37 6.8K
R27 9.1K
R28 27K
R29 470
R30 43
R22 470
R24 5K
R95 200
R96
R97 3.3K
R98 22K
R99 51
R100 82
R101
R102 62
R103 100K
R104 1K
R108 40 20W
R109 SHUNT
R110 250
R111 5K
R93 1K
C8 5μf 65V
C9 200μf 15V
C24 5μf 65V
C26 1μf 35V
C27 .1μf 100V
C28 .082μf 200V
C29 5μf 65V
CR26
CR27
CR28
CR29
CR30
CR31
CR32
CR33
CR34
CR35
CR36
CR61
CR62
CR63
CR64
Q16 .033μf 200V
Q11
Q10
Q20
Q21
T2
A
V
OR G ANT



PATENTS APPLIED FOR ON THIS CIRCUIT. LICENSE TO USE MUST BE OBTAINED IN WRITING FROM HARRISON LABORATORIES

NOTES:
1. ALL RESISTORS ARE ½ W 5% UNLESS OTHERWISE NOTED
2. * DENOTES 20 PPM WIRE TEMP. COFF.
3. REAR TERMINAL STRIP IS SHOWN IN NORMAL STRAPPING
4. – – – – DENOTES VOLTAGE SIGNAL
5. ——— DENOTES CURRENT SIGNAL

HEWLETT hp PACKARD

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